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Brouwers, S.A.

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Culture and Cognitive Transfer in Childhood

Proefschrift ter verkrijging van de graad van doctor aan de Universiteit van Tilburg, op gezag van de rector magnificus, prof. dr. F. A. van der Duyn Schouten, in het openbaar te verdedigen ten overstaan van een door het college voor promoties aangewezen commissie in de Marga Klompé zaal op donderdag 25 september 2008 om 16:15 uur door Sijmen Auke Brouwers, geboren op 26 juni 1976 te Leeuwarden.

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Commissie: prof. dr. A. Demetriou
prof. dr. Y. H. Poortinga
prof. dr. W. C. M. Resing
dr. A. Chasiotis
dr. J. Fontaine

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Table of contents

Introduction 7

1 Variation in Raven's Progressive Matrices Scores across Time and Place 26

2 Schooling and Everyday Cognitive Development among
Kharwar Children In India: A Natural Experiment 63

3 Everyday and School-Specificity of Representational Change:
A Longitudinal Study among Kharwar Children in India 89

4 Natural Variation of Typicality in Childhood: Visual Search
of Ideals and Features in a Multicultural Context 118

Discussion 136

Summary in English 146

Summary in Dutch 151

Introduction

The ability to cognitively transfer information from one situation to another is an important element of everyday human intelligence and it has been widely studied (see Barnett & Ceci, 2002 for an extensive review). Nevertheless, some important questions remain. One of these questions concerns the notion of context. Previous research has shown that success of transfer significantly depends on crossing the temporal, physical, or functional boundaries that separate many contexts from each other. What remains unclear is how specific contexts really are: People are able to transfer knowledge from one context to another on occasion, not on all occasions, but sometimes. On part of the actor, this requires some sort of understanding of why information is linked to specific situations or, alternatively, why it can be transferred to other situations. The present dissertation reports on four studies that investigate how children understand information. The first study starts rather distal to psychological process; it examines country and historical differences in Raven's Matrices scores. The three subsequent studies adopt a more proximal perspective, zooming in on the processes and causes that produce or moderate cognitive transfer. The four studies in my dissertation investigate variations on four of six scales of Cole's (1996) model about the distribution of cognition in time: the history of human beings on earth, the history of the individual's immediate context, the life of the individual himself, and finally the history of moment-to-moment lived experience. Geological time and phylogeny (the first two scales mentioned by Cole) are ignored for now.

The point of entry in the next four studies are the relations between culture and cognition. In this introduction I review the most common perspectives on the cross-cultural specificity of human cognition. Perspectives typically consist of conflicting ideas about the role of cognitive domains in cross-cultural differences and either claim that domains have different function in different cultures or that domains can only be accessed with specific stimuli. After my review of these two main perspectives, I present an alternative: dynamic representation. I conclude this introduction with an outline of the specific themes of each

of the four studies that make up the body of this dissertation.

Access and representation

The specificity of any form of behavior or information processing to particular contexts suggests that contexts access the mental representation of individual actors. The psychological significance of access stems from research of both classical and operant conditioning. A stimulus, usually outside the actor, triggers a response in the actor, when this stimulus has previously been conditioned on the response (Skinner, 1950). A closer examination of the term access in the Oxford English Dictionary and the Van Dale Groot Woordenboek der Nederlandse Taal (for “toegang”) reveals three different definitions: (i) coming to or towards, approaching; (ii) a way or means of approach; and (iii) the license to approach. This more detailed definition of access suggests larger involvement on part of the actor. Psychologically, access is also perceived as being broader than recognized in strict S-R models. Research has shown that people have access to a broad repertoire of mentally represented information and that their success benefits from such information (Bandura, 1977).

Mental representation is one type in a broader family of representations, which also includes painting, poetry and prose. All types of representations share important properties. So are all representations realized through a representation bearer, which is a canvas for painting, a book for poetry, and the human mind for mental representation. Nevertheless, defining mental representation is not a simple task and depends on which metaphor is used to portray the human mind, which is either a rule based system or an associative network, and whether all parts of a representation are accessed at once or whether discrete pieces of information are only accessed one at a time (Von Eckardt, 1999). Typically, it is thought that all parts of a representation are accessed at once (Piaget, 1947/2001; Vygotsky, 1978). The idea that historical and contextual meaning is psychologically intrinsic to isolated constituents of everyday life, such as artifacts, behaviors, and thoughts, still dominates psychology. Apparently, they come with a ‘manual’ that says how, where and when they can be used; at least, that is what researchers seem to think. Nevertheless, support of the belief that historical and contextual meaning is psychologically intrinsic to isolated

constituents of everyday life has waned during the twentieth century. According to James (1909), context is pluralistic, not *uni*-verse, but *multi*-verse. Context thus consists of many distinctive parts, such as home, neighborhood, customs, and task demands, that each has its own specific demands. Following James' analysis, the remainder of this dissertation works from the position that mental representation really is an associative network of discrete pieces of information that are accessed individually.

Culture and cognitive transfer

Research on cognitive transfer has had a long history. The main finding from this research is that children and adults have significant problems with transferring procedures, representations, or principles from one problem or situation to another (Barnett & Ceci, 2002; diSessa, 1993; Wagner, 2006). In fact, several now classic studies demonstrated that children's far transfer did not increase after prolonged training and that training effects are limited to tasks that are similar to the task that was trained (Cole & Bruner, 1971; Cole, Gay, Glick, & Sharp, 1971; Cole & Scribner, 1974; Scribner & Cole, 1981). Research on transfer and nontransfer showed that transfer occurs by a mixture of automatic triggering and intentional mindful abstraction, but transfer is impeded when available information is inert and not sufficiently strong to establish associations between one context and the other (e.g., Salomon & Perkins, 1989). Recognition of the possible inertia of information has in recent decades led to a broader study of domain-specificity. Research on the link between culture and cognition has centered on the issue of whether domains themselves are culture specific (Nisbett, 2003; Sloman, 1996; Stanovich & West, 2000), or whether domains are universally available (Sternberg et al., 2002). Developmental research has shown that from a very young age children recognize goal-directed behavior (Perner, Lang, & Kloo, 2002; Wellman, Cross, & Watson, 2001), living kinds (Inagaki & Hatano, 1996, 2002) and human-made artifacts (Jipson & Gelman, 2007; Kemler Nelson, Frankenfield, Morris, & Blair, 2000). These findings suggest that certain domains are universally available, but do not account for differences in transfer and how these connect to domains.

One way to solve the combination of stable domains and differences in transfer has been to broaden the definition of transfer and to explicitly include a predictive phase in

addition to an inference phase. Transfer from one object property to another involves the inference of one attribute (a psychological property that is general across different situations) from this property and the subsequent application of this attribute to some other property (Barnett & Ceci, 2002). Schematically, this resembles the following course: property → attribute → property (Liu, Gelman, & Wellman, 2007). Lack of transfer is typically attributed to difficulties in the inference of appropriate attributes and research has led to two hypotheses. The first hypothesis states that schooling and culture shape children's internal cognitive structures; the second hypothesis states that schooling and culture only facilitate the ease by which children are able to access universal cognitive structures (Norenzayan & Heine, 2005; Van de Vijver & Leung, 1997). These two hypotheses are discussed in more detail. This discussion is directly followed by an alternative hypothesis that aims to combine the strengths of both established hypotheses, but address their weaknesses.

Socialization of usage

Children from different cultures might show different patterns of transfer because the same stimuli give children from different cultures access to different internal cognitive structures. These variations in internal structure arise by way of culture-specific practices through which they were socialized by their parents or teachers (e.g., Olson, 1994). Socialization facilitates the abstraction of a qualitatively higher level of representation in children. At higher levels of abstraction children are more likely to recognize that relevant procedures, representations, or principles may be transferred from one task to the other and that these procedures, representations, or principles may be mentally manipulated in a detached fashion (Lave, 1988). Schooled children can more easily than unschooled children transfer their existing understanding to novel tasks and materials, using higher levels of abstraction, which enables them to attain a higher rate of cognitive development. Much research has been invested to explore the effect of socialization on transfer (Cole & Bruner, 1971; Rogoff, 1981; Serpell, 1993).

The most important factor for explaining the cognitive consequences of socialization that has ever been proposed is literacy. Oral discourse contains various cues,

such as intonation, that are absent in written texts. When children learn to read they necessarily have to attain a new way of looking at things, a way in which the information available in the text is taken as independent and sufficient for understanding the nature of what is presented (Olson, 1994). Literacy thus stimulates children to attain a more abstract perspective. Scribner and Cole (1981) and Berry and Bennett (1991) studied the impact of literacy on cognitive functioning. In a study among the Vai in Liberia, Scribner and Cole (1981) could avoid the confounding of schooling and literacy, because the Vai have three distinct literacy practices with each having its distinct course of instruction. Literacy showed a much more restricted transfer of skills to other domains of intellectual performance than did schooling. Berry and Bennett (1991) replicated the findings of Scribner and Cole among the Cree in Canada. Both studies suggest that literacy does not explain all performance differences between schooled and unschooled children and that literacy is not a vehicle for attaining a qualitatively higher level of abstraction.

Literacy is not the only way to socialize children. Out-of-context instruction is another relevant way to influence children's way of thinking. Instruction in everyday life is often restricted to a particular situation with an immediate and clear purpose and is less geared toward transfer. Schooling provides children with cognitive challenges not often found in the everyday context and directly taps into the skill of transfer (Bruner, 1966). Yet, despite greater familiarity with decontextualized spatial tasks, children raised in the U.S.A. performed poorer than Mayan children on culturally embedded spatial tasks, familiar to Mayan children as they were derived from the domain of weaving that is common to these children (Maynard & Greenfield, 2003). However, the mass practice in weaving did not produce a high context-independent skill in spatial representation despite substantial skill in pattern weaving among Mayan children (Greenfield & Childs, 1977). Similarly, Lave presented Liberian schooled adults and unschooled tailors with arithmetic problems in both school and tailoring forms of the same nature and complexity (Lave, 1980/1997). While schooling better predicted arithmetic performance on school problems, tailoring experience better predicted arithmetic performance on tailoring problems. These findings contradict the basic assumption that cognitive transfer is a context-independent skill.

Specificity of access

Another reason why children from different cultures are likely to infer different attributes from similar properties is that children need to be familiar with highly specific prompts in order to gain access to the procedures, representations, or principles they all know in the same way. Lack of familiarity with those prompts prevents transfer (e.g., Sternberg et al., 2002). Basic cognitive functioning is thought to be similar for all children across all cultures, but the ways in which it is manifested may vary across cultures. The performance on cognitive tests varies with their ecological validity (Berry, Poortinga, Segall, & Dasen, 2002; Cole, 1996; Ferguson, 1956; Schliemann, Carrahar, & Ceci, 1997; Van de Vijver, 2002). Problems in the inference of attributes thus should be highly specific to distinct content domains. The most basic type of specificity is task-specificity, but specificity can also be broader, so as to include fields of knowledge that consist of factual information, specific strategies, and the knowledge when or how to use these strategies (cf. Alexander & Judy, 1988).

Psychometric and neo-Piagetian (Case, 1985; also see Piaget, 1947/2001) studies of intelligence found that components of cognitive functioning are captured in an overarching structure of cognitive abilities (Carroll, 1993) and that this structure is equivalent across cultures. Advocates of task-specific mechanisms propose that transfer of skill is moderated by the format in which the tasks designed to observe and describe this skill are presented and the extent to which children have been exposed to this task format (Berry et al., 2002; Cole & Bruner, 1971; Dasen & Heron, 1981; Mishra, 1997; Schliemann et al., 1997; Super & Harkness, 1986). Schooling (Rogoff, 1981) and westernization (Mishra, Sinha, & Berry, 1996) make children more familiar with testing, and this familiarity increases their performance on intelligence tests (Helms-Lorenz, Van de Vijver, & Poortinga, 2003; Van de Vijver, 1997). Environmental limitations such as poor schooling, child labor, malnutrition, and pandemics may limit exposure (Fagan & Holland, 2002; Feuerstein, 1979; Sternberg et al., 2002). As a consequence there may be a gap between potential and actual performance.

In order to bridge this gap among rural Tanzanian school children, Sternberg et al. adopted a dynamic testing procedure and familiarized children with performance-

enhancing skills and strategies contributing to success on the administered cognitive tests. Children that underwent familiarization increased their performance from pretest to posttest significantly more than a control group did; pretest-posttest correlations were weak; posttest scores were better predictors of reference measures of mental ability. A meta-analytic comparison of (i) models that see cross-cultural differences as valid intergroup differences in underlying competence and (ii) models that see cross-cultural score differences as a consequence of inadequacies of the measurement instruments found substantial support for the latter (Van de Vijver, 1997).

Cognitive anthropological studies of cognitive ability tend to ignore larger underlying structures and instead argue that competence is more domain specific (Billet, 1996). This research usually adopts a neo-Vygotskian perspective, which conceives of cognitive development as a process of internalization (e.g., Vygotsky, 1978). Sociocultural and communicative interactions in which adults and children participate shape the mental representations that they acquire about particular operations (Cole, 1996; Lave & Wenger, 1991; Rogoff, 1990; Shore, 1996). In distinct sociocultural contexts different representations of the same or totally other skills may emerge. For example, Lave (1988) discusses the shopping activities of some shoppers in a supermarket in the U.S.A., observing that these shoppers have a highly specific system of arithmetic processes for calculating prices and deciding between products in just this particular sociocultural context. One strategy which shoppers use is the gap-closing arithmetic. They decide about the feasibility of a probable resolution by comparing this resolution with the expected solution and adjusting the calculations when necessary. Gigerenzer, Todd, and The ABC Research Group (1999) also noted the highly specific use of heuristics for decision making in specific environments. Although developed in a different school, the work on modules and modularity of cognitive functioning also combines the universality of basic cognitive functions with domain-specific skills (Cole, 1996; Fodor, 1983; Tooby & Cosmides, 1992). Cross-cultural differences may emerge as the result of different sets of modules being developed in each culture. Although the approach seems promising, applications show two problems. First, the number of possible modules is inexhaustible. Second, research on modularity so far has focused on the universality of modules rather than on

their cultural specificity.

Having reviewed research on the socialization of function and the specificity of access, it is clear that the process of inferring attributes from object properties has been well documented in the psychology literature and that there is empirical evidence in favor of both. At the same time, evidence of neither gives a full account of the origin of cross-cultural differences and the two hypotheses might be treated as complementary. Clearly, researchers still struggle with the problem of how to conceptualize the influence of schooling and culture, both separately and jointly, in cognitive functioning (Berry et al., 2002; Shore, 1996). As already discussed above, the process of inferring attributes from properties is not the only phase in property to property transfer. A second phase consists of the prediction and extraction of new properties from the inferred attribute. The richness of people's mental representation is a good facilitator of this predictive phase (Elman, Bates, Johnson, Karmiloff-Smith, Parisi, & Plunkett, 1996; Fauconnier & Turner, 1998; Marcus, 1998, 2001). This line of thinking is discussed in the next section.

Dynamic representation

Everyday life creates an amazing variety of cognitive tasks. Even by looking at something as simple as an evening meal it is easy to be overwhelmed by the dynamics involved (de Certeau, Giard, & Mayol, 1998). For one thing, the meal has to be prepared. Thus, there are the ingredients, the recipes and the time spent behind the stove. It is good to know how many people are going to join, since the table has to be made ready and utensils have to be put out. People should be sitting at the dining table in time, so that the food does not get cold. And then there are still other issues as well, such as the etiquette. Examples include, rules about who is allowed to speak during the meal and who is not, and rules for showing the meal was satisfying. Anyone of these aspects of a meal may give rise to a range of shifting dynamics. What if one parent is absent during the meal or if there are guests? What if one has dietary preferences? What if a particular layout of utensils is necessary for what will be served? What if this meal is in India or in Turkey and not in Sweden or in Italy? Recognizing all these details, all the cognitive, affective and social processes, participation in everyday life looks so very daunting and almost impossible to

actually carry out successfully. Of course, as we all know of others and of ourselves, people accomplish these tasks with remarkable ease.

There is growing appeal for the character of dynamic cognition. Many studies have examined dynamic representation empirically (e.g., Amsterlaw, 2006; Diesendruck, 2001; Diesendruck & Halevi, 2006; Gelman, 2003; Lutz & Keil, 2002). And many other studies have investigated issues that relate to the dynamic nature of cognition (e.g., Bailenson, Shum, Atran, Medin, & Coley, 2002; Barsalou, 1985; Benet-Martinez, Lee, & Leu, 2006; Grigorenko et al, 2001; Schwanenflugel, Henderson, & Fabricius, 1998). Variation in dynamic representation may be between-individuals and within individuals.

The classic constructionist theory of cognitive development does not separate between-individual variation from within-individual variation. Cognitive development is conceptualized as children's gradual construction of culturally shared representations through the continuing internalization of novel but discrete units of information (Piaget, 1947/2001). Through this construction, representations gradually approach some abstract version of reality. A well-known illustration is that of conservation of fluid: Water is poured from one glass into another glass with a different height and width. Children need to tell whether the level of water will be higher or lower. Young children typically attend to one dimension, often height. As they grow older, they start to recognize the other dimension, but in their predictions they only attend to the two dimensions inconsistently. Later they will attend to both dimensions simultaneously and consistently. This consistency may be true for concepts such as conservation, but in many everyday transactions the required operations are usually less fixed, as illustrated by the example of the shared meal. The classic developmental approach does not provide a framework for such within-individual variation, where shifting constellations of operations and features should be recognized and dealt with.

A more contemporary conceptualization seems to deal more easily with dynamic variation in cognition or cognitive development. Instead of building constructs from only a few elements children are thought to develop by means of representational redescription (Karmiloff-Smith, 1992; also see Dienes & Perner, 1999; Pine & Messer, 2000; Reber, 1989). Representational redescription involves the distinction of implicit and explicit

levels of representation.

Implicit representation reflects the intuitive understanding that a disparate collection of different elements can relate to one another in concrete ways (Ahn, Gelman, Amsterlaw, Hohenstein, & Kalish, 2000; Pine & Messer, 2000). Young children understand that integers are distinct marks on a scale (Le Corre, Van de Walle, Brannon, & Carey, 2006). Thus, looking at three dolls and seven toy balls, young children immediately recognize that there are more toy balls than dolls, even when they cannot justify this in explicit numbers. In contrast, explicit representation reflects conventions or rules that are extrinsic to the representation about how discrete units of information are assembled (Barsalou, 1985; Langacker, 1986). Thus, cooking a meal is led by considerations about food preferences, the costs of the ingredients, and the time it takes to prepare these. While all these elements taken together might lead to an implicit understanding of the purpose of the cook (i.e., to feed people) only an explicit understanding of the concrete actions will lead to the actual meal. Only after redescription of the implicit representation into an explicit representation, through the increasing familiarity with relevant features, children may be able to access and actively employ their representation voluntarily. It is in the explicit representation that dynamics can be realized.

This dissertation

My dissertation addresses the complex link between culture and cognition and the question whether success and failure of cognitive transfer should be attributed to children's mental representation. I start with examining quite distal relationships by investigating the differences between countries and differences across historical time in Raven Matrices scores. Gradually a more proximal perspective is adopted, zooming in on the processes and causes that produce or moderate cognitive transfer in childhood. The studies in this dissertation examine dynamic variation at four of six times scales of Cole's (1996) model of the distribution of cognition in time. The model includes six time scales that frame children's experience: the history of the physical universe (geological time), the history of life on earth (phylogeny), the history of human beings on earth (cultural-historical time), the history of the individual's immediate context (ontogeny of the outside), the life of the

individual himself (ontogeny), and finally the history of moment-to-moment lived experience (microgenesis). Geological time and phylogeny are ignored for now.

The first study addresses cultural-historical time in a broad meta-analysis of cultural and historical variation in performance on Raven's Progressive Matrices. Cross-cultural comparisons with the Raven tests are often conducted from the premise that the instrument measures cross-cultural differences in intelligence that are not confounded by other cultural or national differences, such as education and affluence (Raven, 2000; Rushton, Skuy, & Bons, 2004). However, the rise of performance across generations, which is commonly known as the Flynn effect, is now a well-established effect (Flynn, 2007). We examine how the Flynn effect is affected by culture-level variables such as affluence.

The second study addresses ontogeny of the 'outside' in a cross-sectional comparison of schooling and everyday experiences and their separate contribution to children's cognitive development amongst Kharwar children in rural India. The comparison of the separate effects of educational age and chronological age is a better approach for unraveling the cognitive consequences of schooling and everyday experiences, but such a comparison is difficult to implement in practice. Western-based studies would only employ highly correlated measures of chronological and educational age (all children go to school), while Non-Western studies tend to confound educational age with socioeconomic status (mainly children of affluent families go to school). In the present study we take advantage of a specific setting in India, in which neither educational and chronological age, nor schooling and status are confounded, allowing a study design that avoids the usual limitations of schooling effect studies.

The third study is a longitudinal extension of the second study and addresses ontogeny of the child more directly than was done in the (cross-sectional) second study, by looking at variations in impact of the different processes of cognitive development. Originally it was argued that cognitive change over time is linear (Schaie, 1965). This position would suggest that the ratio of the effects of chronological age and educational age remains constant and that there is no shift in emphasis from the former to the latter with more advanced development. In contrast, recent evidence suggests that developmental trajectories do change shape, through dynamic interaction (Fischer & Paré-Blagojev, 2000).

A longitudinal comparison in which chronological and educational age are disentangled from each other is employed to address this issue.

The fourth study is a microgenetic examination of the way by which children may shift from one kind of information to another in order to infer category membership of everyday items (i.e, typicality), among Dutch monocultural and bicultural children. Children may take cues from clearly discernable features, such as physical appearance or statistical properties, but they may also bring a priori goals to the task. Studies of typicality tend to aim exclusively at showing that typicality is a guiding principle in categorization (thus affects the outcome of the inference process), but not at examining the conditions under which typicality may actually show up in everyday life. We realize a natural variation in typicality by selecting stimuli from both Turkish and Dutch cultures and then exposing Turkish-Dutch bicultural children as well as Dutch monocultural children to both kinds of stimuli in a timed visual search task.

Together these four studies examine culture and cognitive transfer in childhood. Dynamic variation at each of the four relevant scales of cognition in time (variation of the Flynn effect across countries with differences in affluence; unique effects of chronological and educational age; distinct patterns of change across chronological and educational age; and the situatedness of typicality) tests the hypothesis that success and failure of cognitive transfer originate from children's mental representation.

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Variation in Raven's Progressive Matrices

Scores across Time and Place

The paper describes a cross-cultural and historical meta-analysis of Raven's Progressive Matrices. Data were analyzed of 798 samples from 45 countries ($N = 244,316$), which were published between 1944 and 2003. Country-level indicators of educational permeation (which involves a broad set of interrelated educational input and output factors that are strongly related to economic development), the samples' educational age, and publication year were all independently related to performance on Raven's matrices. Our data suggest that the Flynn effect can be found in high as well as low GNP countries, although its size is moderated by education-related sample and country characteristics. An equivalent increase in education-related input characteristics in developed and emerging countries seems to bring about a larger performance increase in emerging countries.

Raven's Progressive Matrices are a series of multiple-choice items of abstract reasoning. Each item depicts an abstract pattern in a two by two or three by three matrix; all cells contain a figure except for the cell in the right lower corner. Participants are asked to identify the missing segment that would best complement the pattern constituted by the other cells among a set of alternatives that are positioned beneath the matrix. John C. Raven published the first version of the test in 1938; the three versions of the test (Advanced, Colored, and Standard Progressive Matrices) have since been among the most widely-used intelligence tests. Its intuitively appealing question format and the use of figure stimuli have made the test attractive for cross-cultural comparisons. A meta-analysis

of cross-cultural intelligence test scores found that the test takes a second place after the Wechsler Intelligence Scales for Children (Van de Vijver, 1997). This widespread usage makes the test an interesting instrument for a cross-cultural meta-analysis. Moreover, the period in which the Raven has been used in various countries is long enough for enabling a study of a temporal patterning of test scores. In the present article, we report a meta-analysis of Raven performance of children and adults from 45 countries across a time span of 60 years.

Cross-cultural comparisons with the Raven tests are often conducted from the premise that the instrument measures cross-cultural differences in intelligence that are not confounded by other cultural or national differences, such as education and affluence (Raven, 2000; Rushton, Skuy, & Bons, 2004). 'Culture-free' (Cattell, 1940), 'culture-fair' (Cattell & Cattell, 1963), and 'culture-reduced' (Jensen, 1980) are all terms that have been proposed to describe the Raven or similar tests that do not seem to require much cultural knowledge for answering the items correctly. Particularly the first two labels are not undisputed. As early as 1966 Frijda and Jahoda argued that it is impossible to measure intelligence without the confounding influence of cultural factors, as both the definition of the concept and its expression are cultural. Nevertheless, the Raven tests are still considered to be measures of intelligence that show less influence of confounding cultural factors on the cross-national differences than any other intelligence test.

On a historical level, some role of country characteristics has now been well established. The rise of intelligence test scores over time, which is generally known as the Flynn effect (Flynn, 1987), has been ascribed to such factors as improved nutrition (Colom, Lluís-Font, & Andrés-Puepo, 2005), increased environmental complexity (Schooler, 1998), and socialization practices at home and at school (Williams, 1998). The bulk of research into the Flynn effect is based on people from high affluence countries. Evidence begins to accumulate that the Flynn effect is not confined to high affluence countries or countries that invest strongly in educating its inhabitants. Daley, Whaley, Sigman, Espinosa, and Neumann (2003) were the first to show a Flynn effect outside the twenty largest industrialized countries. In rural Kenya they found that performance on the Raven's Progressive Matrices had undergone a strong increase across the fourteen-year

interval between the pre- and post-tests. The latter study points to the potential cross-cultural generalizability of the Flynn effect. A cross-cultural meta-analysis of Raven test scores across a long period might help to examine this generalizability and to address the role of potentially moderating variables such as educational differences between countries.

In cross-cultural psychology there has long been an influential line of thought in which a distinction is made between intelligence and intelligence test scores (Vernon, 1979). A similar distinction is made in cross-cultural Piagetian psychology: Competence is understood to be quite distinct from performance (Dasen, 1977). The differentiation is thought to accommodate the influence of various, potentially biasing factors that may create a difference between ‘real’ and ‘observed’ intelligence. Examples of these factors may be previous test exposure, cultural appropriateness of an instrument and its administration procedures, in addition to confounding sample characteristics. Van de Vijver and Leung (1997) coined the term ‘method bias’ to refer to the overall impact caused by these confounding factors. There is empirical evidence that such factors contribute to Raven performance. For example, Ombrédane, Robaye, and Plumail (1956) showed that the predictive validity of Raven performance became stronger by repeated administration in a group of illiterate, Congolese mine workers. Retest effects due to method factors are not restricted to non-Western participants and also prevail among Westerners (e.g., Blieszner, Willis, & Baltes, 1981; Wing, 1980). Te Nijenhuis, Van Vianen, and Van der Flier (2007) were able to show in a meta-analysis that gains on intelligence test scores after retesting or intervention tend not to be related to general intelligence (‘g’). These findings are in line with our notion of method bias.

From an ontogenetic perspective, educational indicators relate to the frequency with which people have opportunities for cognitive stimulation. The Raven’s Progressive Matrices are measures of reasoning and in order to reason people need opportunities for learning how to transform given information into conclusions (Galotti, 1989). Vygotsky (1978) directly related education to the potential gap between competence and performance. He reasoned that performance only reflects one’s actual level of development and thus only the development that is already completed. Working in rural Tanzania, Sternberg and colleagues examined the utility of dynamic testing of school-attending

children (Sternberg et al., 2002). They familiarized children with the skills and strategies that are thought to contribute to success on tests of cognitive ability. A significant gain in test scores after training was observed, which was not present in the untrained group (which received the same tests the same number of times). The relationship between educational indicators and test performance at country level cannot be solely interpreted as a simple increase in intellectual functioning through schooling. The influence of test bias should also be taken into account; the Raven might contain elements that benefit people from one country more than people from another country.

Educational indicators such as expenditure per capita, educational level of teachers, and enrolment rates have been shown to predict country-level scores on cognitive instruments (Van de Vijver, 1997). Educational quality indicators are known to belong to a cluster of variables that denote economic development (Georgas, Van de Vijver, & Berry, 2004). Some other variables in this cluster are enrolment into primary, secondary, and tertiary education, Gross National Product, percentage of population working in service industry, use of mass media, prevalence of telephones, and population growth (the last one with a negative relation).

We present here a meta-analysis of studies that reported data on Raven's Progressive Matrices, comprising samples of children and adults from 45 countries covering a period of 60 years. Publication year, educational permeation (a broad set of interrelated educational input and output factors at country level), and educational age are the three most important variables that are examined in the analysis. Based on the literature, we expect the performance on the Raven to increase with educational age (operationalized as the average number of years of schooling of the study sample) and indicators of educational quality (at country level), and we expect an increase of performance scores over time (Flynn effect).

Method

Sample

Studies that report data on Raven's Progressive Matrices were located through PsycInfo (1887 to 2003), the Social Sciences Citation Index, the Researcher's

Bibliography for Raven's Progressive Matrices and Mill Hill Vocabulary Scales (Court, 1995), and the catalogue of Dutch libraries. In addition, a request for data was sent to 200 authors around the world, plus mailing lists in relevant research areas. Other reports were found through snowballing on the basis of reference lists in studies already identified. Data that concerned Standard Progressive Matrices (SPM), Colored Progressive Matrices (CPM), and Advanced Progressive Matrices II (APM II) were included. Sample sizes and raw mean or median scores had to be available for all cases. Clinical populations, mentally retarded groups, and other samples selected solely on the basis of intellectual capacity were not included in the present study.

The total sample consists of 193 studies; scoring all individual samples separately for age and gender resulted in a total number of 798 subsamples; the total sample size was 244,316. The data set includes data from 45 countries and covers the period from 1944 to 2003. Table 1 presents the distribution of the 798 subsamples across 45 countries and 60 years of publication. There is a clear bias in the distributions across country and year of publication. The United Kingdom, the United States of America and Poland have seen many studies, whereas countries as varied as Venezuela, Syria, Sweden, South Korea, Qatar, Norway and Mexico have all seen only one study (and most countries have never seen any study). The distribution of studies over time is skewed towards the present, with particularly high numbers for the period between 1984 and 1993. The same is true for the number of cultures per year. Data from many cultures were reported in the mid-1990s studies, but data from very few different cultures were reported until 1981. Of the different versions (APM, CPM and SPM) the SPM is by far the most used (62.3% of 798 samples), followed by the CPM with 27.3% and the APM with only 10.4%.

Measures

Study and sample characteristics. Relevant sample and study characteristics were taken from the individual publications. The raw mean, standard deviations of every raw mean, mean age of the participants, mean number of years of schooling, and gender were recorded (if available). The year of publication of the studies was also recorded.

Country-level characteristics. Relevant country-level characteristics were gathered

Table 1

Frequencies of Studies per Country and Year of Publication

Characteristics	Number of studies
Countries	
Congo, France, Mexico, Norway, Qatar, South Korea, Sweden, Syria, Venezuela	1
Austria, Belgium, Brazil, Denmark, Egypt, Germany (East), Iceland Ireland, Japan, Kenya, Nigeria, Singapore, Spain,	2 to 10
Czechoslovakia, Ghana, Hong-Kong, Israel, Italy, The Netherlands, Romania, Taiwan, Tanzania, Yugoslavia	11 to 19
Argentina, Australia, Canada, China, Germany (West), India, Iran, New Zealand, Poland, Slovakia, South Africa, United Kingdom, United States of America	more than 20
Year of publication	
1944-1953	61
1954-1963	26
1964-1973	25
1974-1983	126
1984-1993	408
1994-2003	152

from databases that the United Nations and other institutes provide on their Internet sites. Gathered in this way were Gross National Product per capita in 2007 (GNP; Gross Domestic Product, 2007), and a number of characteristics related to the education in each country, such as illiteracy, rates of enrollment into education, and the number of pupils per teacher (Georgas et al., 2004).

In order to examine the dimensionality of the education-related characteristics at country level, illiteracy rate, enrollment into primary, secondary and tertiary education, and

the number of pupils per teacher were factor analyzed. A first factor with an eigenvalue of 2.83 was found to explain 56% of the variance. Illiteracy rate had a loading of -.83 on the factor, enrollment in primary education one of .09, enrollment into secondary education one of .93, enrollment into tertiary education a loading of .76, and the number of pupils per teacher a loading of -.83. The low loading of primary enrolment probably reflects the limited cross-country variability in this variable because of the universality of compulsory primary schooling. The factor covers a broad set of interrelated educational input and output factors and was labeled educational permeation.

Results

Descriptives

All scores were transformed from their raw mean to a 0-100 scale, depending on the number of items that were administered in the particular samples. Performance on Raven's Progressive Matrices ranged from 10 to 97, with an overall mean of 61.88 and a standard deviation of 15.97. Standard deviations were available for 512 of the 798 samples; they ranged from 1.00 to 28.84, with a mean of 6.88 and a standard deviation of 3.09. Both chronological and educational age showed large ranges. Chronological age ranged from 3.00 to 82.50 years, with a mean of 16.72 and a standard deviation of 13.94; educational age ranged from 0 to 17.17 years, with a mean of 5.84 and a standard deviation of 3.89. Sex effects could not be addressed. Nine studies did not report participants' sex, while 485 samples had some mixture of both males and females and could not be further broken down. Of the 288 remaining samples, 175 samples were entirely composed of males and 113 of females.

Initial Analyses

In order to estimate the effect of country on Raven performance, a univariate ANOVA was conducted with performance as the dependent variable and country as grouping variable. The effect of country on performance is significant, $F(44, 753) = 4.79$, $p < .001$, partial eta-squared = .22. Cohen (1988) proposed boundary values for small, medium, and large effects of .01, .06, and .14, respectively. The effect size observed here

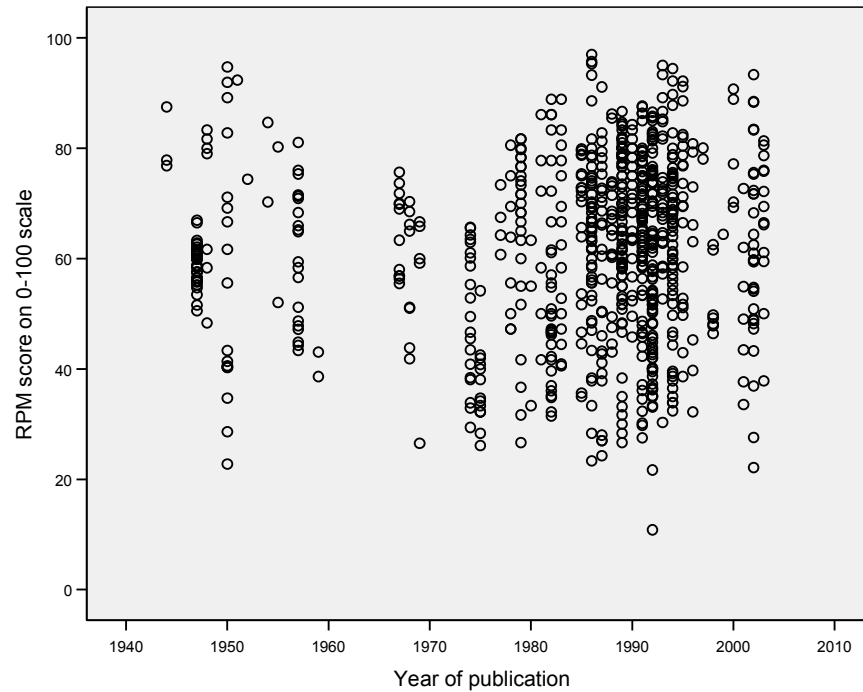


Figure 1. Performance on Raven's Progressive Matrices plotted against year of publication.

is thus large. In order to estimate the effect of year of publication on Raven performance, a univariate ANOVA with performance as the dependent variable and year of publication as the grouping variable was carried out. The effect of year of publication is significant, $F(40, 757) = 3.55$, $p < .001$, and large, partial eta-squared = .16. Figure 1 presents the pattern of performance over time. A visual inspection does not suggest a clear patterning despite the large effect; mean performance does not look different for the 50s than for the 90s. It looks as if there are differences between years that are not part of any long-term trend.

Figures 2 and 3 visually present the change of performance on Raven's Progressive Matrices across chronological and educational age, respectively. The relationship between

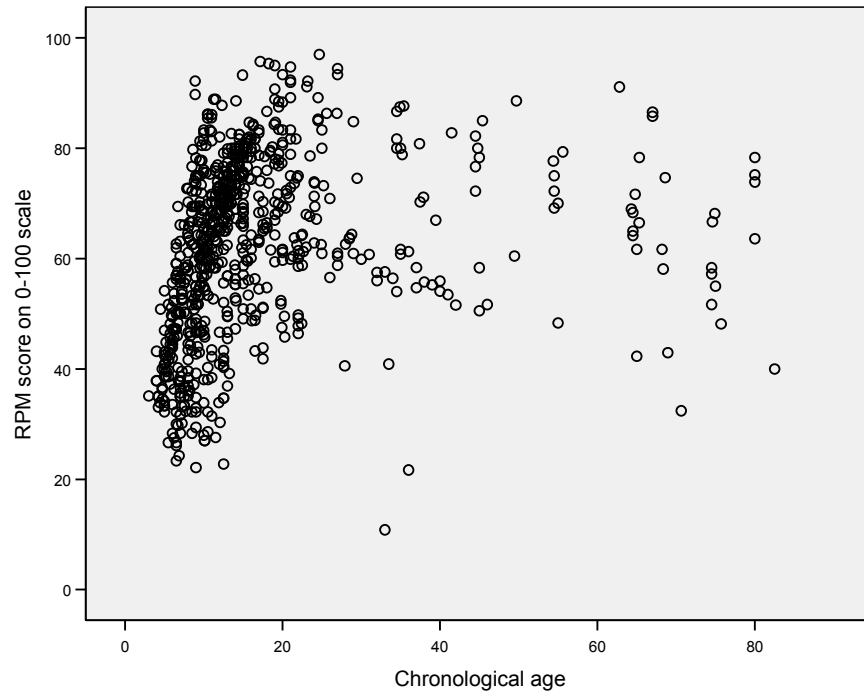


Figure 2. Performance on Raven's Progressive Matrices plotted against chronological age.

chronological age and performance corresponds to that what is typically found in the literature (e.g., McArdle, Ferrer-Caja, Hamagami, & Woodcock, 2002; Salthouse, 1996). There is a sharp increase of performance across childhood, adolescence, and early adulthood, which is followed by a gradual decline until old age. The lower scores among the older cohorts appear to be common across the three versions, although the APM shows the strongest effect (not further documented here). To what extent this finding is due to the relative small sample of APM studies will have to remain open. Another source of the lower scores seems to be the lower educational age of older cohorts, as explored below in more detail. Figure 3 shows the relation between educational age and performance. A positive association of test scores and educational age is clearly visible.

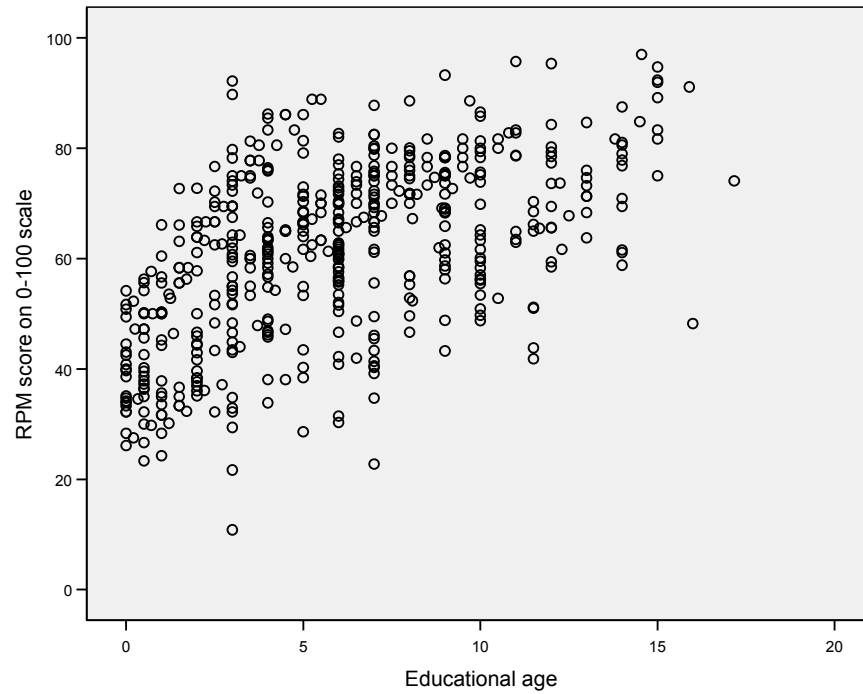


Figure 3. Performance on Raven's Progressive Matrices plotted against educational age.

Correlational and Regression Analyses

Correlations between relevant sample, study, and country characteristics are presented in Table 2. Educational age correlated significantly with year of publication, $r(514) = -.19, p < .001$. The direction of the relation between educational age and year of publication is striking. More recent studies apparently sampled participants with on average lower educational ages than earlier studies. Until the age of twenty chronological age and educational age correlated almost perfectly, $r(444) = .96, p < .001$, but the correlation was (almost significantly) negative for people over the age of twenty, $r(54) = -.24, p = .08$. The lack of significance of this latter correlation is probably due to the small number of people aged older than twenty in the study samples. The relations between these

Table 2

Correlations between Sample-, Country-, and Study-Level Characteristics

Characteristics	Chronological age < 20 yr	Chronological age > 20 yr	Educational age	GNP
Sample characteristics				
Educational age	.96***	-.24		
Country characteristics				
Gross National Product	-.01	-.00	.04	
Educational permeation	-.05	.10	.05	.79***
Study characteristics				
Year of publication	-.13**	.21**	-.19***	-.08*

* $p < .05$. ** $p < .01$. *** $p < .001$.

characteristics and Raven performance are addressed in the next section.

Table 3 presents the correlations between Raven performance and seven of the sample, study and country characteristics. As can be seen at the top of the Table, sample and country characteristics are significantly related. At sample level, both chronological age for people that are younger than twenty years and educational age correlated significantly with performance, $r(614) = .23$, $p < .001$ and $r(514) = .56$, $p < .001$, respectively. At country level, educational permeation and Gross National Product correlated positively with performance on the Raven, $r(709) = .25$, $p < .001$ and $r(709) = .16$, $p < .001$, respectively. These two positive correlations suggest that basic educational and everyday conditions of countries can statistically account for a relevant part of cross-cultural differences in performance on the Raven.

The Flynn effect would be observed if test performance and year of publication are

Table 3

Correlations between Performance on Raven's Progressive Matrices and Sample-, Country-, and Study-Level Characteristics^a

Characteristics		<i>R</i>
Sample characteristics	Chronological age < 20 yr	.58***
	Chronological age > 20 yr	-.14
	Educational age	.56***
Country characteristics	Gross National Product	.16***
	Educational permeation	.25***
Study characteristics	Year of publication (original)	.07
	Year of publication (partial) ^b	.22***

*** $p < .001$. ^aAll scores were transformed from their raw mean to a 0-100 scale and then averaged across the Advanced, Colored, and Standard Versions. ^bThe partial correlation between year of publication and performance was corrected for educational age and educational permeation.

positively associated. As can be seen Figure 1, the relation is weak (though marginally significant), $r(798) = .07$, $p = .05$. The weakness of the relation could be a consequence of moderators not accounted for. More specifically, the educational situation of samples may be crucial, both in terms of participants' educational age as in terms of countries' educational permeation. Educational age was positively related to performance, but as shown in Table 2, educational age was negatively related to year of publication. When educational age and educational permeation were included as controlling variables in the estimation, the correlation between Raven performance and year of publication became .22 ($p < .001$). Thus, after controlling for sample- and country-related educational characteristics, we observed the expected Flynn effect in performance on Raven's Progressive Matrices.

The importance of sample and country characteristics in moderating the Flynn effect

is further underscored in a regression analysis. Performance on the Raven was the dependent variable, while year of publication, educational age, and educational permeation were predictors. The proportion of explained variance in performance is large, $R^2 = .41$, $p < .001$. The relation between educational age and performance is strong and significant ($\beta = .59$, $p < .001$). Educational permeation has a somewhat smaller effect on performance, but the effect is still significant ($\beta = .26$, $p < .001$). A small, though salient Flynn effect can be derived from the positive relation between performance and year of publication ($\beta = .18$, $p < .001$). The regression analysis demonstrates that while the zero-order correlations of our predictors with Raven performance are not significant, the regression coefficients (that can be viewed as partial correlations) are significant.

The regression analysis implies that the Flynn effect is universal. A final analysis addressed this claim in more detail by testing the presence of the effect in individual countries. A country was included in the analysis if data from this country met three criteria: The country should be present in the dataset in at least 20 samples; data of the country should be collected on at least two independent occasions; data of the country should have a minimum dispersion of 14 years from the earliest to the latest occasion. Eight of out 45 countries in the dataset met all criteria (namely Australia, Canada, the former West-Germany, India, Iran, Poland, United Kingdom, and the United States). For each country a separate regression analysis was conducted with year of publication and educational age as predictors and Raven test score as dependent variable. The results are presented in Table 4. Canada showed a significantly negative regression coefficient for year of publication. This might signify a reversed Flynn effect, but this cannot be assured from the present analysis. United Kingdom was the only affluent country with a salient Flynn effect. The largest Flynn effects were found in India, Iran, and Poland. The size of the Flynn effect showed a significantly negative correlation with the Gross National Product of the country, $r(8) = -.74$, $p < .05$. Unfortunately, countries from Africa and South America were only measured at single occasions. We do not know whether the negative correlation extends to developing countries. It can be concluded that our data suggest a temporal patterning in the Flynn effect; the effect was first observed in Western countries where it may have reached its ceiling, while countries with a lower, though increasing

Table 4

Size of the Flynn Effect by Country (Standardized Regression Coefficients)

Country	Frequency		B	R^2
	Years	Samples		
Australia	7	35	-.26	.33**
Canada	8	20	-.52**	.68***
Germany (West)	8	25	-.05	.40*
India	8	41	.62***	.44***
Iran	2	22	.64***	.95***
Poland	5	72	.55***	.60***
United Kingdom	14	129	.53***	.52***
United States	17	99	-.01	.20**

* $p < .05$. ** $p < .01$. *** $p < .001$.

level of economic development show a more pronounced Flynn effect.

Discussion

We examined the associations between performance on Raven's Progressive Matrices with various education-related country characteristics and year of publication. A total of 193 publications were included in our meta-analysis, which contained 798 independent samples from 45 countries and covering a history of 60 years. This considerable variation in countries and years of publication is crucial for testing the cross-cultural generalizability of the Flynn effect. A regression analysis showed that year of publication has a relation with Raven performance that is independent of individuals'

educational age and country's educational permeation. Moreover, educational age was the best predictor of Raven performance. These analyses revealed that each of the three variables created unique patterns of change and thus tap into different aspects of performance on Raven's Progressive Matrices.

Our analysis suggests the Flynn effect is not an artifact of the on average higher levels of education of samples in countries with growing economies (that tend to invest more in education). Yet, a growth in economic development and the accompanying larger investment in education could boost the size of the Flynn effect if the development would not be accounted for in the analyses. The current study suggests that three factors are independently associated with an increase in Raven scores: educational permeation, educational age, and publication year. Two of these factors, educational permeation and educational age, will often act in concert; economic growth over an extended period will often lead to more educational permeation and to an increase of the average educational age of a population. If the Flynn effect is observed in a country with a substantial economic development in the period of observation, the size of the effect may be boosted by the economic development.

The current study suggests that differences in Raven scores should not be interpreted only from the individual-level perspective. Also important are test and country characteristics. The Raven, as do many other tests, may contain elements that show differential suitability across cultures (Van de Vijver, 1997). The present study provides support for this perspective. The contribution of educational permeation to performance in addition to the Flynn effect, which we found in the present analysis, suggests that factors such as test bias and need for achievement might play a role in cross-cultural differences in Raven test scores.

The Flynn effect was independent from education-related characteristics, which suggests that it is an effect that is present in all countries represented in our meta-analysis. One critical question that emerges after our analysis is whether there was enough temporal and cross-cultural variation in the data set to assert the universality of the Flynn effect. It could be argued that a sample size of 45 countries is sizeable; however, the cultural variation in this sample is not optimal. An inspection of Table 1 suggests that affluent

Western countries and developing countries are overrepresented; moreover, it is only for some, mainly Western, countries that a sizeable variation in years of publication is available. As a consequence, one could argue that the variability in our data set is limited. Still, our data suggest that Flynn effect is not linked to Western societies alone and is independent of individual-level and country-level education-related factors.

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Schooling and Everyday Cognitive Development among Kharwar Children in India: A Natural Experiment

The confounding of chronological and educational age and of schooling and socioeconomic status are persistent problems in the study of the cognitive consequences of schooling. The educational system among the Kharwar in India provides a natural experiment to overcome these problems, since it shows neither source of confounding. The sample comprised of 201 schooled and unschooled Kharwar children from six to nine years of age. The test battery contained tests of mathematics and memory with formal and local stimulus content, as well as tests of inductive reasoning, analogies, fluency, picture vocabulary, and numbers. Confirmatory factor analyses supported similar hierarchical factor structures, with general intelligence in the apex, for both unschooled and schooled children. The per annum score increments of chronological age were about twice as large as those of educational age. These findings illustrate the important role of everyday experiences in the development of basic features of cognitive functioning.

Schooling is a setting where teachers and pupils conspire to elevate pupils' degree of generalization. This "conspiracy" is motivated by the perception that generalization offers an advantage in the processing of cognitive tasks that cannot be achieved with unique rules for each task. Despite this perception, the psychological foundation of cognitive generalization in school is underexposed. Broadly speaking, there is disagreement about

the mechanisms that can explain the effect of schooling. Comparisons of school-attending and unschooled children can easily lead to "great divide models" of schooling effects, in which observed differences between these two groups of children are often interpreted as qualitative in nature (Tulviste, 1991; Vygotsky, 1978). We propose that this type of comparison cannot reveal the effects of schooling adequately. Schooling effects, like cross-cultural differences, are less dichotomous and more continuous than assumed in studies contrasting schooled and unschooled individuals (Berry, Poortinga, Segall, & Dasen, 2002). Therefore, we propose that a comparison of the effects of educational age and chronological age might be a better approach for unraveling the cognitive consequences of schooling and everyday experiences. However, such a comparison appears difficult to implement in practice. Western-based studies may only employ highly correlated measures of chronological and educational age, which seriously limits their power to disentangle cognitive effects of both kinds of age. Non-Western studies show another confounding, educational age tends to be related to socioeconomic status in these studies. In the present study we take advantage of a specific setting in India, in which neither educational and chronological age, nor schooling and status are confounded, allowing a study design that avoids the usual limitations of schooling effect studies (Mishra & Dasen, 2004).

A need to disentangle educational age from chronological age stems from observations that each has unique contributions to similarities and differences in cognitive development. The contributions of chronological age were predominantly addressed by Piaget (1947/2001). He holds that children gradually assimilate operations, such as manipulations of objects and symbols like addition and conservation, and that these operations together constitute their level of operativity. Schooling effect studies tend to address differences in general level of operativity, also labeled psychometric *g* (Case, Demetriou, Platsidou, & Kazi, 2001), between school-attending and unschooled children. Contributions of educational age were virtually pretty much neglected by Piaget, but are central in Vygotsky's (1978) work. He proposes that schooled literacy leads to a qualitative jump in children's level of operativity. In our view, an underexposed aspect in the discussion of the effects of schooling is the sequence in which experiences of everyday

and school appear in children's lives. Experiences with cognitive operations during everyday settings tend to precede experiences with the same operations in school. Although everyday experiences stimulate the acquisition of operations, they do not bring the development process to fruition (Case, 1985, 1992). Schooling adds to the child's skill to apply an operation by teaching strategies and other transfer-enhancing tools.

Research of the past few decades has shown that the development of operations does not automatically include knowledge about how to apply them. Strategies that help to apply operations only seem to emerge during clear-cut practice in well-defined environments (Case, 1992; Dasen & Heron, 1981). The role of school as just one particular context for the development of strategies has been demonstrated by Posner (1982) in her examination of the arithmetical skills of five to ten year old children of two tribes in Ivory Coast that differ in exposure to everyday arithmetic. Schooled and unschooled children of both groups were equally skilled in executing basic arithmetical operations, such as addition, signifying the effects of everyday experiences on the overall level of operativity. Still, children without much everyday experience in arithmetic started to use more efficient strategies when they had attended school. The use of efficient strategies allows children to perform closer to their true potential. Sternberg et al. (2002) examined the utility of providing school-attending children from a rural area in Tanzania with strategies that helped to work more efficiently. Significant gains in reasoning were observed. Posttest scores were much better predictors of reference measures of mental ability than were pretest scores. Beneficial effects of test strategies are widely found in cross-cultural psychology (Ombrédane, Robaye, & Plumail, 1956; Van de Vijver, Daal, & Van Zonneveld, 1986).

We propose that schooling creates its own domains of strategic knowledge. This view is illustrated in the work of Lave (1980/1997). She showed that schooled Liberian adults found it difficult to use their numerosity skill when solving mathematical tasks that were embedded in tailoring tasks and they indeed performed worse than unschooled Liberian tailors. Schooling does not induce transfer to other tasks by forming operations at higher levels of operativity. Working with the Vai of Liberia, Scribner and Cole (1981) compared the cognitive test performance of illiterate adults without schooling, literate

adults without schooling, and literate adults that were formally schooled. Literates in Vai deviated from illiterates in small, but consistent ways. Differences concerned the specific syllabic characteristics of the Vai script, and did not transfer to more remote tasks. High levels of specificity in differences between schooled and unschooled literates of an indigenous script were replicated among the Cree in Canada by Berry and Bennett (1991). Schooling affords children with tangible gains in development that typically focus on their efficient problem solving strategies and not on their operativity (Case et al., 2001; Ferguson, 1956; Mishra, Sinha, & Berry, 1996; Schliemann, Carrahar, & Ceci, 1997; Van de Vijver, 2002).

Three distinct types of psychometric studies are usually employed to examine schooling effects on development (Ceci, 1990, 1991; Christian et al., 2001; Crone & Whitehurst, 1999; Stelzl, Merz, Ehlers, & Remer, 1995). The first two have only been conducted in Western countries: summer holiday and birthday cutoff studies. Summer holiday studies have shown that a sustained absence of schooling during the summer holiday leads to a decline in cognitive test performance (Ceci, 1990). Birthday cutoff studies provide two different comparisons. First, such studies compare relatively young with relatively old first-graders. This comparison shows convergence of the performance of the younger and older pupils after one year of schooling. Second, they compare children at the end of the first grade with children of about the same age who are not yet enrolled. A year of schooling leads to a difference in performance between the two groups of children (Ceci, 1991; Stelzl et al., 1995). However, both summer holiday and birthday cutoff studies only employ measures of educational age and group differences in scores over brief time periods; these studies cannot address the long-term effects of schooling over and above everyday experience.

The third type is usually carried out in developing countries that have moderate levels of school attendance because of low enrolment or high dropout rates. These studies employ indicators of group educational age and chronological age that are less strongly related (e.g., Serpell, 1993). However, in such countries school attendance is usually related to socioeconomic status (Rogoff, 1981). Only high-status families are able or willing to pay the school fee. Confounding of status and school attendance may lead to a

selection bias in a comparison of schooled and unschooled individuals (Ceci & Williams, 1997). Compared to unschooled children, school-attending children probably have a more stimulating family background and more frequent exposure to literacy before school attendance. Thus, the natural contexts of these studies do not provide a complete disentanglement of chronological and educational age and hence, their validity can be challenged.

We propose a fourth type of psychometric design: natural experiments (Scheier, 1959). A natural experiment takes place at a site where threats to common designs do not exist (Mishra & Dasen, 2004). A natural experiment of schooling effects is provided by a context in which chronological and educational dates are not confounded. Examples of natural experiments of schooling effects among adults are studies by Scribner and Cole (1981) and Berry and Bennett (1991). Our study addresses schooling effects in children. Among the Kharwar of rural Uttar Pradesh (Northeastern India), age of enrollment into primary education varies considerably, enabling the recruitment of children with various combinations of educational and chronological age. For example, we included seven-year old children without any schooling, with one year of schooling, and with two years of schooling. Moreover, selection biases that typically challenge a comparison of school-attending and unschooled children are small: all participants in the study are from the same (lowest) caste and socioeconomic status is relatively homogeneous among villagers. It is clear that this research site avoids the common confounds of educational and chronological age, and of schooling and social and economic status.

Two hypotheses are tested. First, we expect that unschooled and school-attending children will perform at the same level on our embedded tests (i.e., instruments that were specifically developed for the Kharwar by employing items that were close to their everyday experiences), while the school-attending children will outperform unschooled children on the formal tests (i.e., tests with a more school-related content). Second, we expect that the type of instruction that is specific to a schooling context has no effect on cognitive development beyond the effect provided by everyday experience. This expectation implies that educational age does not predict individual differences in performance better than chronological age.

Method

Setting

The study was carried out among the Kharwar, a cultural group living around the border that divides southeast Uttar Pradesh from western Jharkhand. The sample in this study was drawn from nine villages located on a forested plateau south of the Ganges-valley. A few years ago, these villages were part of Varanasi district, but now they are part of a newly created district called Chandauli. The villages are contained in the Naugarh Block area, which is the remotest region of Chandauli district. Situated at a distance of about 100 km south of the city of Varanasi the whole region is still quite underdeveloped. The region is generally inhospitable and the villages are isolated and inaccessible. Naugarh is a small market place that caters to the day-to-day needs of villages situated at distances between 8 to 25 km. Roads from Naugarh to neighboring villages are in a poor state or are absent altogether. Due to this isolation, people have very little exposure to the outside world. Animism is the predominant belief system, but Hindu rituals and festivals are also observed and celebrated.

The Kharwar have a subsistence level of economy that is based on growing rice and gathering produce in the forest, although the latter is in decline because of governmental prohibition on the use of forest resources. The villagers have to depend largely on rain-fed crops, because the soil has very little water retention capacity and the facilities for irrigation are meager. Being close to the forest the crops also attract wild animals. As a result, the villagers usually have agricultural produce that is barely enough for three to four months. For the rest of the year, they have to depend on forest resources and animals. Food patterns depend on the season, brought about by the availability of forest produce and the scarcity of agricultural products like rice in the months following the monsoon season. People in the villages thus also talk about "food months" (when the food is in abundance) and "hunger months" (when there is very little food available). Malnutrition is common among children. Due to the lack of safe drinking water, diarrhea is an important health hazard.

In the Kharwar community, all children are expected and encouraged to participate in a variety of everyday chores and activities and in this way parents promote the

development of operations in their children from an early age. As a consequence, all children have experiences that foster such operations like conservation, causality, and seriation, all of which can be expected to contribute to children's overall level of operativity during development. Social events such as taking care of babies and running errands make children aware of the relationships between antecedents and consequences and even though this is a particular event with unique causes, it might lead to the expectation of causality in many other settings and reasoning processes as well (Tomasello, 1999). Purchasing of small items from local shops does not only provide exposure to causality but also requires children to carry out simple arithmetical procedures. As villages border immediately on forests and fields, children also have close experience of their natural surroundings, prevailing weather and the effects of rain and drought, presumably also supporting the development of causality and conservation. Counting skills are generally more pronounced in the herding of livestock, which is an important activity that children are engaged in, initially with adults, later independently. Although livestock is the property of individual families, they are looked after collectively and as such children learn to count animals that belong to them and those that belong to other families. The major activity of children is the collection of an indigenous type of nut from the forest. This nut grows at the heart of the leaves of a particular tree, but is only ready to be collected when the leaves have colored yellow. Children thus learn to be sensitive to the color of leaves. Sensitivity to the peculiarities of leaves is also useful for the production of plates and cups. Since the plates and cups will later serve actual purposes, their construction has to follow exact patterns and children learn to thread together leaves with the help of small twigs according to predetermined patterns. In summary, the everyday life of Kharwar children can be viewed as providing a variety of cognitive stimulants that serve to produce growth in overall level of operativity.

Education has been introduced fairly recently in this region. Because of a strict reliance on agricultural and gathering occupations in this region, there is no demand for jobs requiring formal education. Having livestock is a guarantee for milk products, eggs, or wool, which can be used for own consumption or for trade. Being educated does not guarantee alternative means of acquiring of consumptive products. For this reason schools

were met with a high degree of skepticism at their introduction, but during the last decade interest has grown by way of social and agricultural developmental work. Moreover, the Indian government provides parents and the community with a variety of incentives to send children to school. Poverty and status are not related to the enrollment in and attendance of school. Children can be enrolled into school at the start of the school year at any age following their sixth birthday. It is common to find children of different ages at the same grade level, which in itself is a great challenge for the education of children in a single classroom.

Participants

Two-hundred-and-one children between the ages of six and nine years took part in this study. Children were recruited by a local NGO. Following detailed pointers about the natural experiment of this study, a collaborator from this NGO traveled to many villages to check for availability of children, and a list was compiled. Parents of children eligible for enrollment in the study were consulted and their permission was requested. No financial compensation was provided. Diversity in age of enrollment and availability of unschooled children at successive ages enable a study of the independent effects of chronological and educational age. In Table 1 the distribution of the fourteen groups and the exact number of participants are presented. Each group consisted of more or less equal numbers of boys and girls.

Instruments

We aimed at measuring the children's overall level of operativity directly as it is assumed to constitute children's total amount of growth over a given period of time. Because psychometric g is equivalent to overall level of operativity (Case et al., 2001) and psychometric tests may be easier to administer in a battery like-style than more complex Piagetian tasks, psychometric tests were developed. A broad range of psychometric measures were chosen from Carroll's (1993) model of cognitive ability. This model of human cognitive abilities by Carroll is based on a re-analysis and integration of over 460 data sets, found in the factor-analytic literature. In the model, domains of reasoning, verbal

Table 1

Numbers of Children per Age and Grade^a

Grade	Age				Total
	6	7	8	9	
Unschool	11	11	10	13	45
	(4, 7)	(5, 6)	(5, 5)	(6, 7)	(20, 25)
1	24	10	9	9	52
	(11, 13)	(5, 5)	(5, 4)	(4, 5)	(25, 27)
2		21	10	10	41
		(9, 12)	(5, 5)	(5, 5)	(19, 22)
3			27	9	36
			(13, 14)	(4, 5)	(17, 19)
4				27	27
				(15, 12)	(15, 12)
Total	35	42	56	68	201
	(15, 20)	(19, 23)	(28, 28)	(34, 34)	(96, 105)

^aThe numbers of boys and girls are placed between the brackets.

learning, memory and others are a midlevel between more specific measures and psychometric g. Seven cognitive instruments plus a biographical questionnaire were administered to children. For two instruments both formal and embedded versions were developed, making a total of nine tests (see Table 2 for an overview).

Inductive Reasoning. The measurement of formal inductive reasoning was done using Raven's Colored Progressive Matrices. It was chosen here since it is appropriate for research with participants from cultures who are unfamiliar with the more abstract format of the Standard Version. The Colored Version includes 36 matrices arranged in three sets of 12 matrices, in varying difficulty. For the present purpose a shortened version with two

Table 2
Overview of the Instruments

Domain	Instruments	
Inductive Reasoning	Subset of Raven Colored Progressive Matrices	
Embedded Analogies	Prediction and postdiction across time	
Picture Vocabulary	Recognition of pictured objects	
Fluency	Enumerating items from questioned categories	
Numbers	Counting of pictured objects	
	Formal	Embedded
Mathematics	School-like math problems	Story-embedded math problems
Memory Span	Free recall of words	Free recall of objects

example matrices and 18 scored matrices was employed. The number of items was reduced because a pilot study showed that the administration of the full version discouraged the children, which carried over to consecutive tests. The internal consistency (Cronbach's alpha) was .70.

Embedded Analogies. In order to measure embedded reasoning Sternberg and Kalmar (1998) developed an instrument dealing with state changes of objects. Each item involved an object in a particular state and subjects had to predict the future state of that object or postdict its past state by choosing one of three displayed states on a computer screen. Four items with a similar layout as Sternberg and Kalmar's, but now using small, concrete models of real-life objects familiar to children in this cultural setting, were developed for the present study: (1) What will be the length of this girl in two years from now? (2) What will be the level of water in this bottle in one month from now? (3) What

was the color of this yellow leaf three days ago? (4) What will be the length of this tree in ten years from now? Children could choose from three alternatives. Internal consistency was .40. This value was low, probably due to the small number of items.

Mathematics. Children were asked nine mathematical questions in two different ways. In the formal manner the same kind of questions were asked as in school, such as: "How much is two plus two?" The same questions were also embedded in stories, such as: "Sawita saw two birds this morning and two this afternoon. How many birds did she see today?" The nine test items consisted of three additions, three subtractions, and three multiplications. All items were open-ended and scored as either correct or incorrect. The internal consistency was .87 for the formal and .86 for the embedded version.

Picture Vocabulary. Fourteen pictures were taken from children's posters. The objects these pictures depicted were familiar to the children in this age group and culture. Children had to name these pictures. When the object was named correctly, a score of two points was given; when the response was incorrect but fell in the same category (e.g., naming a melon an orange) one point was given; in other cases no point was given. For each child the sum was calculated. The internal consistency was .65.

Fluency. Children were asked to enumerate as many objects as possible from three different categories: things to eat, animals, and boys' and girls' names. The number of correct objects per category was determined and summed to a total score. The internal consistency, measured as the correlation across the three category scores, was .40.

Numbers. Three drawings (depicting three pots, eight faces, and seventeen birds, respectively) were created and presented to the children. These were asked to count the number of objects in each drawing. The three items were scored as either correct or incorrect. The internal consistency was .52.

Memory Span. This test has two forms. First, a formal version using twelve words with three words coming from four categories each: food, beauty products, tools, and animals. The words were read slowly in a random order, after which the child was asked to recall the words. Second, an embedded version using twelve concrete objects from the same categories as the words. The objects were taken randomly from a bag and put in front of the child. After the last was shown the objects were covered with a towel and the child

was asked to recall the objects. All correctly recalled words and objects were scored as one and the missing as zero. The correlation between the number of correctly recalled words and the number of correctly recalled objects was calculated as indicator of internal consistency of the memory span test. This correlation was $r(201) = .40, p < .01$.

Socioeconomic characteristics. A questionnaire was administered to assess several socioeconomic characteristics, including the educational level of the father, the number of siblings, and the number of livestock the father owns.

Procedure

The tests were administered individually. Duration of the administration of the tests took approximately one hour for each child. Data collection was done over a period of five weeks in November and December 2001.

Three experienced experimenters administered the tests. They belonged to the local community, had ten years of schooling, and each one worked as a primary school teacher in one of the villages. Thus, these experimenters were well known to the children and their cultural practices, which presumably helped to reduce test anxiety in the participating children. The experimenters received training prior to testing.

Results

Descriptives

In order to examine the dimensionality of the socioeconomic characteristics, educational level of the father, number of siblings, and number of livestock owned by the father were factor analyzed. A first factor was found with an eigenvalue of 1.19, explaining 40% of the variance. Educational level of the father had a loading of -.77, number of siblings a loading of -.72, and the amount of livestock owned by the father a loading of .30. The factor was labeled Status.

Table 3 shows the correlations between the background variables (age, grade, gender, and status). The correlation between age and status was small, though significant, $r(201) = .16, p < .05$; parents with higher status send their children to school at a later age. As expected in our design, which recruited children from the lowest caste and from a small

Table 3
Correlations between the Background Variables

	Age	Grade	Gender
Grade	.48**		
Gender	-.06	-.05	
Status	.16*	.03	.00

* $p < .05$. ** $p < .01$.

number of homogeneous villages, the correlation between grade (being unschooled is scored as zero) and status was not significant, $r(201) = .03$, $p = .73$. There was a positive and significant correlation between age and schooling, $r(201) = .48$, $p < .01$. This correlation, which may seem unexpected, is a consequence of the incomplete crossing of both variables, as indicated in the triangular shape of the design of Table 1. A fully factorial design would have required the inclusion of impossible combinations (e.g., children of six years of age with four years of schooling). It may be noted that the positive correlation does not challenge the adequacy of the study design (and hence, the interpretability of the results), as each group has a sizable number of children with a specific combination of age and amount of schooling, thus enabling a regression analysis with orthogonal coefficients for chronological and educational age.

Hypothesis Testing

Hypothesis 1: Differences in performance on the formal tasks and embedded tasks.

The hypothesis was tested in two different analyses of variance with repeated measures. The first tested the within-subject differences on the measures that have both a formal and an embedded version. For Mathematics and Memory Span both versions had the same number of items. The main effect of test version is highly significant, Wilks' Lambda = .57, $F(1, 200) = 147.69$, $p < .01$. The measures showed an effect in line with expectation:

performance on Embedded Mathematics was significantly higher than on Formal Mathematics, Wilks' Lambda = .74, $F(1, 200) = 70.14$, $p < .01$; and Object Span was significantly longer than Word Span, Wilks' Lambda = .75, $F(1, 200) = 66.06$, $p < .01$.

The second analysis added schooling (two levels: school-attending vs. unschooled children) as a between-subject factor, which allowed for a comparison of the relative performance on the embedded tests separately for schooled ($N = 156$) and unschooled ($N = 45$) children, using chronological age as covariate. The gap between schooled and unschooled children was significantly smaller for Embedded Mathematics than for Formal Mathematics, Wilks' Lambda = .98, $F(1, 200) = 4.17$, $p < .04$; yet, the proportion of variance accounted for by this factor is small ($\eta^2 = .02$). Memory Span did not show this differentiation, Wilks' Lambda = 1.00, $F(1, 200) = .28$, $p < .66$. Only the Mathematics test behaved fully in line with the first hypothesis. The performance difference on formal and embedded tests seems to be equal for schooled and unschooled children.

Intermezzo: Clustering of the test measures. Confirmatory factor analysis was used to test an a priori specified model based on Carroll's (1993) hierarchical intelligence model. The nine tests were taken to constitute the lowest level and (with the exception of the Raven) to cluster into three second-level domains: Conceptual Reasoning, Mathematics, and Memory. The domains of Conceptual Reasoning and Mathematics were assumed to make up Crystallized Intelligence, which is the part of intelligence that contains information learned during development. The Raven is not included until the highest level, where it clusters together with Crystallized Intelligence and Memory into g , general intelligence.

In order to test this conceptual model, two empirical models were tested: one standardized per chronological age group (because the expected relation between age and test-performance could otherwise induce an age factor) and one standardized per educational age group. Figure 1 shows the results of both factor analyses. Both models showed an excellent fit. The fit statistics of the model standardized per chronological age group were: $\chi^2(23, N = 201) = 27.20$, $p = .25$, the Tucker-Lewis Index (TLI) = .98, the Root Mean Square Error of Approximation (RMSEA) = .03, and the Goodness of Fit Index (GFI) = .97. The fit statistics of the model that was standardized per educational age group

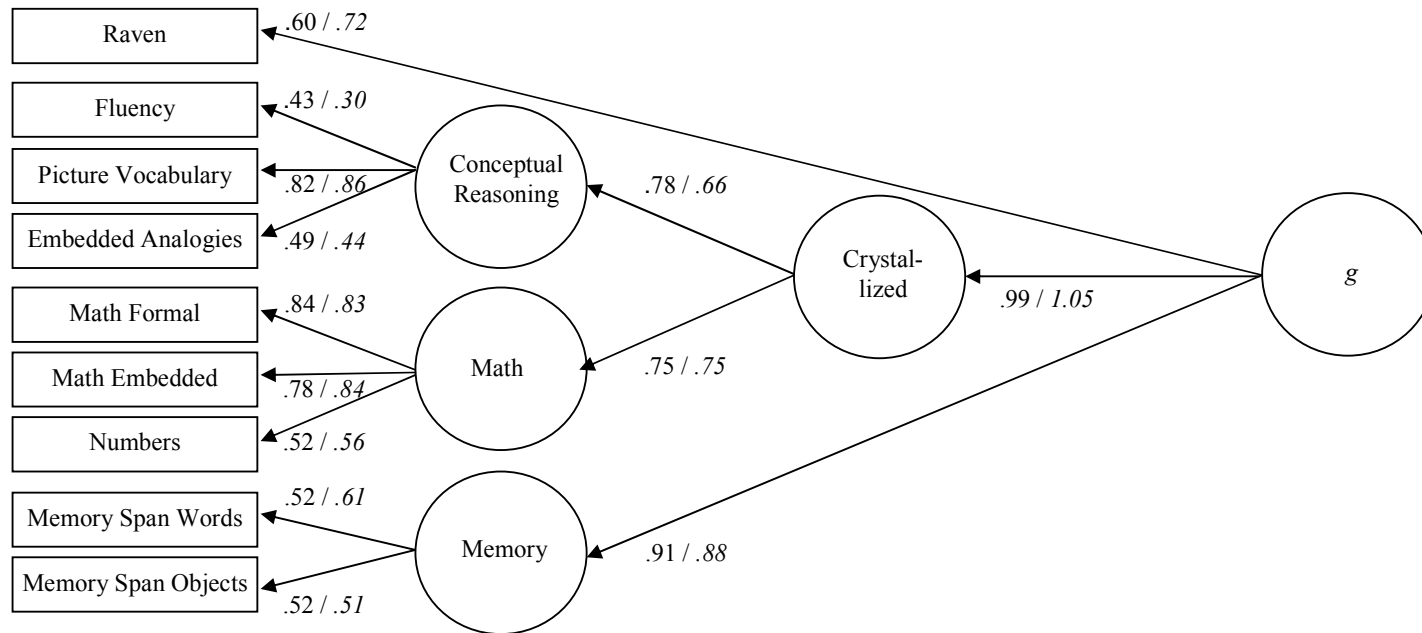


Figure 1. Path model between the nine observed variables and the four hierarchically arranged cognitive constructs (standardized solution).
Notes. The coefficients in regular font are based on the standardization per chronological age; the coefficients in italics are based on the standardization per educational age. All coefficients differ significantly from zero ($p < .01$).

were: $\chi^2(23, N = 201) = 25.91, p = .31$, TLI = .99, RMSEA = .03, and GFI = .97. In both models all factor loadings were positive and significant. The two models cannot be tested for their equivalence, since they are based on the same group of children, but the large overlap in the analyses suggests that the cognitive structure as measured by the test battery is identical across educational and chronological age.

The loadings of g in Figure 1 may not seem in line with the current literature (Carroll, 1993) as Crystallized Intelligence is a better indicator of g than is the Raven. The relatively high loading of crystallized components on g may be due to their extensive representation in the current battery. As a consequence, g may contain more aspects of crystallized intelligence than would be obtained in a test battery containing a larger number of fluid tasks.

Hypothesis 2: The relationships of age and grade with performance. A path model was used to evaluate the relationships between age, grade, status, and gender on the one hand, and the three cognitive domains on the other. Based on the taxonomy of the cognitive tests of Figure 1, non-standardized scores were computed for the Raven, Crystallized Intelligence, and Memory. These were used here as (observed) output scores, which together make up a latent variable called g . The background variables were used as predictors of g and the output measures (see Figure 2). The fit of the model is excellent: $\chi^2(6, N = 201) = 7.96, p = .24$, TLI = .98, RMSEA = .04, and GFI = .99.

Standardized path coefficients are shown in Figure 2. The relationship between chronological age and g is strong ($\beta = .65$) and significant ($p < .01$). It was surprising to find a relationship between Gender and g ($\beta = .28, p < .01$); girls performed poorer than boys. Grade did not have a relationship with g . The proportion of explained variance in g is large, $R^2 = .53, p < .01$.

A casual glance at Figure 2 might incorrectly convey the impression that age is not related to the Raven, Crystallized Intelligence, and Memory. However, the relation between age and these factors is not direct, but goes through g . The net relationship between Age and the Raven is .42 ($p < .01$), which is the product of the significant path coefficients between Age and g (.65) and between g and the Raven (.64). A bootstrap procedure confirmed the significance of this indirect effect. Grade was not related to the

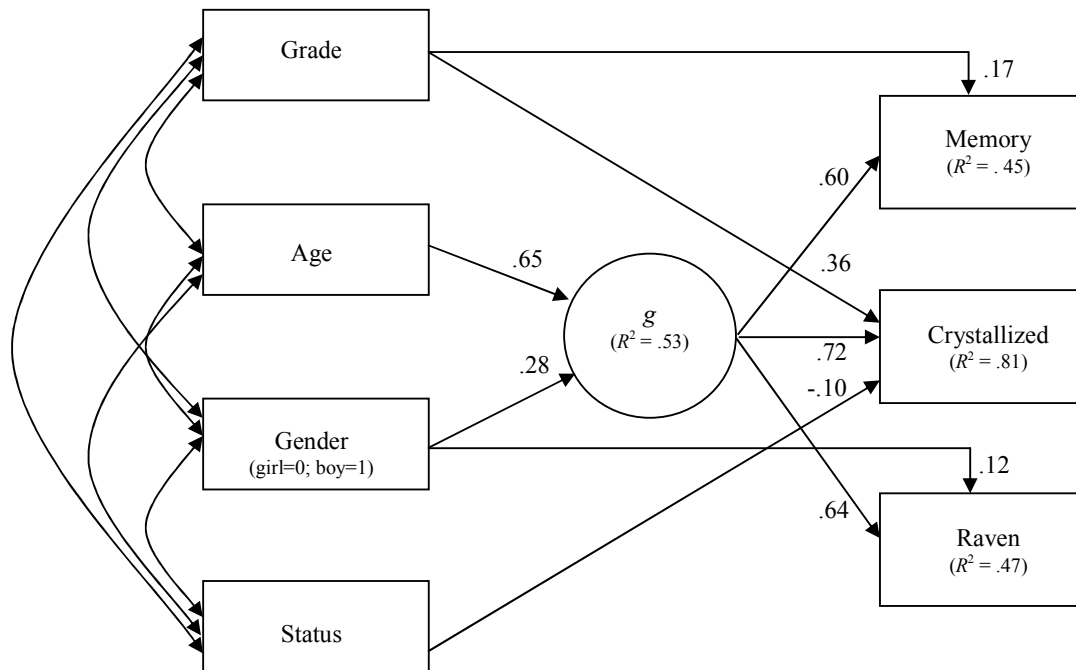


Figure 2. Path model of the regression of the four observed indicators on the four hierarchically arranged cognitive constructs (standardized solution). *Note.* The effect of Gender on Raven is not significant. All other coefficients are significant ($p < .01$).

Raven. The direct relationship between Gender and Raven was not significant, $\beta = .10$, $t(200) = 1.79$, *ns*. Girls did not score significantly lower on the Raven than boys. This may indicate that the earlier observed difference between boys and girls in *g* is probably due to the prominence of a crystallized element in *g*. The proportion of predicted variance of the Raven was .47, which is substantial.

Grade was significantly related to Crystallized Intelligence, $\beta = .36$, $p < .01$. The net relation between Age and Crystallized Intelligence was .47 (.65 x .72), which is significant. Thus, Crystallized Intelligence was not more influenced by Grade than by Age. The relation between Status and Crystallized Intelligence was negative but significant, $\beta = -.10$, $p < .01$. The combination of *g*, Grade, and Status predicted 81% of the variance of Crystallized Intelligence, which is a very large number.

The direct relationship between Grade and Memory was positive and significant ($\beta = .17$, $p < .01$), while the indirect relationship between Age and Memory obtained a much higher value of .39 (.65 x .60), which is significant. Grade and *g* together predicted 45% of the variance of Memory. In summary, the model confirms the second hypothesis. The model of Figure 2 does not give any evidence for the often assumed large influence of schooling on intelligence domains and on *g* in particular.

A more detailed account of the relationship between test performance and chronological and educational age can be derived from Table 4, in which the effect sizes (Cohen's *d*) of all nine test measures for ages 7, 8, and 9, and grades 1, 2, 3, and 4 are given. The effect sizes were calculated as the mean of the group of interest minus the mean of the reference group (defined as the previous age or grade) divided by their pooled standard deviation. The means used in calculating the effect sizes were generated by carrying out two analyses of covariance; in the first chronological age was the grouping variable and grade the covariate, and in the second grade was the grouping variable and chronological age the covariate. The computation of adjusted scores is necessary for allowing the differences in the means to be attributed to their grouping variable without the confounding of the covariate. The covariance analyses confirmed the overall distinction between chronological and educational age: Across age all test measures except Fluency differed significantly, whereas across grade Raven and Memory Span for Words did not

Table 4
Effect Sizes per Age and per Grade for All Test Measures

	Age ^{a, b}				Grade ^{a, c}				
	7	8	9	<i>M</i>	1	2	3	4	<i>M</i>
Inductive Reasoning	.35	.25	.54	.38 **	.39	-.15	.10	-.10	.06
Embedded Analogies	.22	.35	.09	.22 *	.10	.53	.12	-.19	.14 **
Mathematics									
Formal	.23	.69	.38	.43 **	.48	.41	.47	.42	.44 **
Embedded	.30	1.08	.29	.56 **	.52	.11	.29	-.25	.17 **
Picture Vocabulary	.01	.47	.23	.24 **	.72	.16	.23	-.11	.25 **
Fluency	-.02	-.16	.00	-.06	-.41	.62	.16	.30	.17 **
Numbers	.36	.71	.24	.44 **	.57	.33	-.19	-.08	.16 **
Memory Span									
Words	.50	.40	.09	.33 **	-.21	.51	-.16	-.09	.01
Objects	.40	.29	.26	.32 **	-.11	.03	.66	.40	.24 **
<i>M</i>	.26	.45	.24	.32	.23	.28	.19	.03	.18

^aEach previous age or grade is taken as the reference group. ^bThe effect is corrected for grade. ^cThe effect is corrected for chronological age. *Note.* Asterisks indicate that mean effect sizes differ significantly from zero: * $p < .05$. ** $p < .01$.

show significantly different group means. Values of Cohen's d were larger for age than for grade: For age, all effects except one (Fluency) were larger than 0.2 (the cutoff value of a

small effect size); the effect size of embedded Mathematics was even larger than 0.5 (the cutoff value of a medium effect size); for grade only three out of nine (formal Mathematics, Picture Vocabulary, and Memory Span for Objects) showed effect sizes larger than 0.2. Overall, the effects of chronological age were about twice as large as the effects of educational age. Similar patterns of results were obtained when the analyses were performed on individual items (rather than test scores), but these results are not presented here for the sake of space.

Discussion

This study attempted to disentangle the effects of everyday experiences and schooling on cognitive test performance. Research carried out in Western countries cannot lead to an accurate estimate of the cognitive consequence of schooling and everyday experience because of the strong positive correlation between educational and chronological age in countries with high school attendance. The study of schooling effects among the Kharwar in India provided a natural experiment to distinguish between the effects of the everyday environment and school. Neither socioeconomic status and school attendance, nor educational age and chronological age were confounded. Children with ages ranging from 6 to 9 and being unschooled or attending grades 1, 2, 3, and 4 were split into fourteen groups so as to constitute the sampling design given in Table 1. In line with contemporary thinking on the development of skills both embedded and formal tests were employed (Berry et al., 2002; Mishra, 1997; Schliemann et al., 1997).

A straightforward comparison of unschooled and school-attending children yielded results partially similar to those obtained by birthday-cutoff studies. As hypothesized, it was found that school-attending and unschooled children scored higher on embedded tests than on formal tests. Furthermore, school-attending children scored higher than unschooled children, both on embedded and formal tests. The superior performance of school-attending children can already be seen among six-year olds, which replicates findings of birthday-cutoff studies (Ceci, 1990, 1991; Stelzl et al., 1995). However, this higher performance of school-attending children should not be taken to imply that they think in a way that is qualitatively different from the way that unschooled children think.

Standardization on either chronological age or educational age yielded similar factor structures, suggesting that there are no major qualitative differences between school-attending and unschooled children in cognitive functioning in our sample. This evidence is in agreement with the cross-cultural literature, in which the structural equivalence of cognitive tests across many cultural groups with major differences in level of education is reported and a great divide of cognitive differences is challenged (cf. Berry et al., 2002; Irvine, 1979; Van de Vijver, 2002). Equivalence of cognitive structures across school-attending and unschooled children thus validates Piaget's (1947/2001) claims that everyday experience through chronological age is the motor of the development of operations and that they are not subject to effects of educational age, as Vygotsky (1978) suggested.

The direct comparison of the increases in performance on tests of general mental ability across educational age and chronological age shows that school attendance has a substantially smaller impact on competence than has the natural stimulation provided by everyday life. On average, the increase caused by one year of chronological age is twice the increase caused by one year of schooling. Moreover, schooling effects on tests of cognitive ability are confined to those cognitive domains that are somewhat removed from and less related to basic operativity (Carroll, 1993) and primarily benefit from the knowledge of factual details. Thus, the views of both Piaget (1947/2001) and Vygotsky were partly confirmed in the current study. We concur with Piaget in his view of the crucial role of chronological age in the development of operations; yet, his neglect of educational age is not fully justified. We concur with Vygotsky (1978) when he claimed that schooling has an effect on cognitive development; yet, in our comparison of educational and chronological age, the influence of the former is restricted and primarily related to strategies that are confined to school-related domains. Schooling induces the use of strategies without affecting children's level of operativity (Posner, 1982).

A drawback of a natural experiment such as the one presented here is that school quality cannot be manipulated. Even though just small amounts of schooling of only low quality have been shown to produce dramatic effects it cannot be denied whether a lower or higher quality in the schools of our study could have induced other school effects (Fuller & Clark, 1994). In a study of schooling effects, the effects of schooling might be

larger, relative to the effects of chronological age, if variability in the quality of the schools in a chosen field site is higher.

Despite this drawback of the quality of the schools in the current study, we are confident that our observations lend support to the emerging perception that stimulation provided by the setting of children, in which parents play a pivotal role, is sufficient for operations to emerge. As is increasingly appreciated, parents' efforts to provide children with age-appropriate scaffolding and to have their children participate in chores such as fetching objects and running errands, is related to their ethnotheories of intelligence (Grigorenko et al., 2001; Ogunnaike & Houser, 2002). Many operations simply develop through parental scaffolding, while schooling helps children to acquire efficient strategies through the increased supply of factual information (Lave, 1980/1997; Posner, 1982; Scribner & Cole, 1981; Sternberg et al., 2002). Our focus on level of operativity permits us to transcend specialized capacities such as mathematics and address their concurrence in cognitive development with a single model. A core unit of operativity should be distinguished from manifestation in everyday practice when we describe the consequences of schooling. Universal potential may well be accompanied by cross-cultural differences in specific domains and lead to cross-culturally distinct forms and levels of development (Ferguson, 1956; Schliemann et al., 1997).

Our study complements Scribner and Cole's (1981) study by relating children's overall level of operativity to unconfounded measures of educational age and chronological age. We confirm that schooling broadens the field of application of thinking, but that it does not really constitute new thought processes. This point of view was already espoused in 1971 by Cole and Bruner: "The teacher should stop laboring under the impression that he must create new intellectual structures and start concentrating on how to get the child to transfer skills he already possesses to the task at hand" (Cole & Bruner, 1971, p. 874). Generalization in school is thus very much a matter of provoking children to try their operations on a diversity of tasks. Children should be granted a much more active role in their own learning, with their teacher's assuming a more facilitative role.

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Everyday and School-Specificity of Representational Change: A Longitudinal Study among Kharwar Children in India

Variation in children's modes of development across chronological and educational age is studied in India by means of a two-wave longitudinal design with a three-year interval among 191 children aged between 6 and 12 years. Effects of chronological and educational age could be estimated separately from each other. Five measures of implicit and explicit representation were administered. Confirmatory analyses revealed two processes of change: One that reflects children's hierarchical construction of knowledge and another that reflects the actualization of knowledge across particulars. Analyses of the net development per year revealed a decrement of the effect of chronological age and an increase of the effect of educational age. This finding shows that novel input affects children at the end of middle childhood differently than it does young children.

Children towards the end of middle childhood treat new information in a way that is quite different from that of very young children. For very young children new information is more associated with the categorization of behavior (Perner, Lang, & Kloo, 2002; Wellman, Cross, & Watson, 2001), human-made items (Jipson & Gelman, 2007; Kemler Nelson, Frankenfield, Morris, & Blair, 2000) and living kinds (Inagaki & Hatano, 1996, 2002), whereas for children towards the end of middle childhood new information is more

associated with the transfer of properties and the consideration of similarity (Barnett & Ceci, 2002; Fisher & Sloutsky, 2005; Jolicoeur, Gluck, & Kosslyn, 1984; Sloutsky & Fisher, 2004). A shift from categorization to transfer may be deduced from different lines of research, but so far evidence of this shift has been circumstantial (Gelman & Williams, 1998). In the present study we examine this shift more directly by comparing the effects of chronological and educational age in a two-wave longitudinal study with an interval of three years. Previous research found that both everyday and school experiences contribute to children's development and that both predict the performance on intelligence tasks (Cahan & Cohen, 1989; Ceci, 1990). In an earlier cross-sectional study with schooled and unschooled children in India, we showed that chronological and educational age (respectively) relate more to competence and achievement facets of intelligence (Brouwers, Mishra, & Van de Vijver, 2006). A longitudinal design allows us to take a closer look at intra-individual processes of change and to see how chronological and educational age relate to this shift.

To understand the nature of age-related change in cognitive development, psychologists have begun to examine the implicit and explicit character of representation (Karmiloff-Smith, 1992; also see Dienes & Perner, 1999; Reber, 1989). Implicit representation reflects the intuitive understanding that a disparate collection of different elements relate to one another in concrete ways (Ahn, Gelman, Amsterlaw, Hohenstein, & Kalish, 2000; Pine & Messer, 2000). Young children understand that integers are distinct marks on a scale (Le Corre, Van de Walle, Brannon, & Carey, 2006). Thus, looking at three dolls and seven toy balls, young children immediately recognize that there are more toy balls than dolls, even when they cannot justify this in explicit numbers. In contrast, explicit representation reflects conventions or rules that are extrinsic to the representation about how discrete units of information are assembled (Barsalou, 1985; Langacker, 1986). Thus, cooking a meal is led by considerations about food preferences, the costs of the ingredients, and the time it takes to prepare these. While all these elements taken together might lead to an implicit understanding of the purpose of the cook, to feed people, only an explicit understanding of the concrete actions will lead to the actual meal.

To highlight the age-related shift in emphasis from implicit to explicit

representation we juxtapose the chronological age and educational age trajectories (Larivée, Normandeau, & Parent, 2000). Originally, it was argued that change over time is linear (Robinson, Schmidt, & Teti, 2005). This argument, derived from the general developmental model proposed by Schaie (1965), suggests that chronological and educational age have the same influence and that there is no shift in emphasis from the former to the latter with more advanced levels of development. In contrast, more recent evidence suggests that developmental trajectories change shape through dynamic self-organizing interaction (Fischer & Paré-Blagoev, 2000). Development is triggered by new input, which can lead to changes in either children's implicit or explicit representation of that input. This change in their representation has consequences for the way that future input could trigger development.

Changes due to chronological age are thought to be large in the beginning, but to gradually decline with age (Kail & Ferrer, 2007). Such a course of development is assumed to reflect a hierarchical construction of knowledge (Piaget, 1947/2001; also see Bradmetz, 1996; Case, 1991; Demetriou, Christou, Spanoudis, & Platsidou, 2002; Fischer & Immordino-Yang, 2002; Flavell, 1963). Illustrative of this course of development is research on essentialism (Gelman, 2003). Research has shown that certain concepts such as numerosity (Le Corre, Van de Walle, Brannon, & Carey, 2006), vitality of living kinds (Simons & Keil, 1995), and the sequence of events that underlie probability (Reber, 1989), are already present at very young ages, but that the concepts get more elaborated and differentiated as development continues. For example, children gradually differentiate their number concept, when they move from counting numbers on their fingers to basic retrieval strategies in order to solve arithmetic problems (Siegler, 1999, 2000). Changes across chronological age are thus best characterized as *differentiation*.

Changes due to educational age are thought to be weak at the age of enrolment, but to increase gradually with the time spent in school (Elman, Bates, Johnson, Karmiloff-Smith, Parisi, & Plunkett, 1996; Marcus, 1998, 2001; Van Geert, 1991). This route of development is thought to reflect the establishment of associations between existing explicit representation and new discrete units (Fauconnier & Turner, 1998). Illustrative of this course of development is cross-cultural research (Berry, Poortinga, Segall, & Dasen,

2002), which has shown that the way by which people actualize their implicit representations tend to be highly specific to their culture (Cole, 1996), their context (Chavajay & Rogoff, 1999), and particular situations (Lave, 1988), but that the range of ways in which they may assemble their knowledge increases with every additional discrete unit. For example, Lave (1980/1997) showed that schooled Liberian adults found it difficult to use their numerosity skill when solving arithmetical tasks that were embedded in tailoring situations. They actually performed worse than the Liberian tailors who were not formally schooled. Also working in Liberia, but amongst the Vai, Scribner and Cole (1981) compared success on cognitive tests of illiterate adults that were unschooled, with that of literate adults that were unschooled, and literate adults that were unschooled. They showed that literates in Vai did not differ much from illiterates but syllabic characteristics of the Vai script did create small but stable advantages. Development across educational age is thus best characterized as *actualization*.

This theoretical juxtaposition of chronological and educational age highlights the shift in emphasis of developmental processes, but the almost perfect correlation between both ages in cohorts of school-going children in developed countries makes it difficult to really tease apart their distinctive effects on representational development (cf. Flavell, Beach, & Chinsky, 1966). With such high correlations, autonomous effects of individual variables might not be identifiable (Cahan & Cohen, 1989; Ceci, 1990; MacKinnon, Fairchild, & Fritz, 2007). In the present study, we make use of a natural experiment, which is here a setting where the population does not exhibit this confounding (Scheier, 1959). Some examples of natural experiments of school effects among adults are studies by Scribner and Cole (1981), which was discussed above, and Berry and Bennett (1991). Our study addresses schooling effects in children. Aim of the present study is to employ two-wave longitudinal data to examine the effects of both chronological age and educational age without the often seen confounding of both ages (Mishra & Dasen, 2004).

Data were collected among the Kharwar, who are living in rural Uttar Pradesh in Northeastern India. The age of enrolment in primary education varies considerably in this location and the children who attend school do this for different lengths of time. This natural variation allows us to include in our study children at varying ages with different

amounts of schooling between the two test administrations, including several groups without any schooling. Many selection biases that typically challenge studies that compare chronological age and educational age, such as lower dropouts from school amongst boys and amongst children at lower socioeconomic strata, were small because all children came from the same lowest caste and the socioeconomic status across all villages included in our sample is relatively homogeneous. Children were tested twice, with an interval of three years. We examine the hypothesized shift in the way children treat new information, by way of three hypotheses: (1) Our measures cluster into two modes of representation, implicit and explicit representations, and each is associated with different processes of change. Whereas implicit representation is more associated with changes through differentiation, explicit representation is more associated with changes through actualization; (2) as consequence of the operation of these two processes, the strength of the cohesion between distinct competencies declines with advanced stages of development; (3) educational age and chronological age relate to different components of representation. More specifically: (a) Chronological age is more associated with implicit representation, whereas educational age is more associated with explicit representation; (b) Chronological age is more associated with decreasing increments in cognitive test scores, and educational age more with increasing increments.

Method

Setting

The study was carried out among the Kharwar, a society located around the border that divides southeast Uttar Pradesh from western Jharkhand. The sample of the study was drawn from nine villages located on a forested plateau south of the Ganges-valley. A few years ago, these villages were part of Varanasi district, but now they are part of a newly created district called Chandauli. The villages are contained in the Naugarh Block area, which is the most remote region of Chandauli district. Situated at a distance of about 100 km south of the city of Varanasi, the whole region is still quite underdeveloped. The region creates harsh conditions for human habitation and the villages are isolated and inaccessible. Naugarh is a small market place that caters to the day-to-day needs of villages

situated at distances between 8 to 25 km. Roads from Naugarh to neighboring villages are badly damaged or are absent altogether. Due to this isolation, people have very little exposure to the outside world. Animism is the predominant belief system, but Hindu rituals and festivals are also observed and celebrated.

The Kharwar live at a subsistence level of economy by growing rice and gathering forest produce, although the latter is in decline because of governmental prohibition on the use of forest resources. The villagers have to depend largely on rain-fed crops, because the soil has very little water retention capacity and the facilities for irrigation are meager. Being so close to the forest, the crops attract wild animals. As a result, the villagers generally end up having agricultural produce for only up to three or four months. For the rest of the year, they have to depend on forest resources and animals. Food patterns depend on the season, brought about by the availability of forest produce and the scarcity of agricultural products, such as rice in the months following the monsoon season. People in the villages thus also understandably talk about “food months” (when there is food in abundance) and “hunger months” (when there is very little food available). Malnutrition is common among children. Due to the lack of safe drinking water, diarrhea is an important health hazard.

Among the Kharwar, children are expected and even encouraged to participate in a variety of everyday chores and activities. In this way parents foster the comprehension and processing of information by children from an early age. For example, within the village surroundings children are supposed to be taking care of babies, cleaning of the house, running errands, and purchasing little items from local shops. Outside the villages, besides collecting firewood and leaves (for making plates), one major activity of children is the collection of an indigenous type of nut from the forest. This local nut grows at the heart of the leaves of a particular tree, but is only ready to be collected when the leaves have colored yellow. Children thus have to learn to be sensitive to the color of the leaves. Herding of livestock is another important activity children participate in, initially with adults, but later on their own. Even though livestock is the property of individual families, they are looked after collectively. Therefore, all children learn to count animals that belong to them and those that belong to other families. Since the villages border immediately on

the forests and fields, children also have first-hand experience of natural surroundings, the prevailing weather and the effects of rain and drought. In summary, the community of the Kharwar children can be viewed as having a rich variety of cognitive stimulation.

Education has been introduced fairly recently in this region. Because of a strict reliance on agricultural and gathering occupations in this region, there is no demand for jobs requiring formal education. Having livestock is a guarantee for milk products, eggs, or wool, which can be used for own consumption or for trade. Because being educated did not guarantee better living conditions, schools were met with a high degree of skepticism at their introduction. During the last decade, however, interest has grown by way of social and agricultural developmental work. Moreover, the Indian government provides parents and the community with a variety of incentives to send children to school. As a result, poverty and status (there is a small variation within those dimensions in the population) are not related to the enrollment in and attendance of school. Children can be enrolled into school at the start of the school year at any age following their sixth birthday. It is common to find children of different ages at the same grade level, which in itself is a great challenge for the education of children in a single classroom.

Participants

One-hundred-and-ninety-one children took part in the study, the youngest being six years of age at the first test administration and the oldest being twelve years of age at the second test administration that took place after three years. Children were recruited with the help of a local NGO. After detailed instructions about the natural characteristics of the sample, a collaborator from this NGO traveled to many villages to check for the availability of children and compile a list. Parents of children eligible for inclusion in the study were consulted and their permission was requested. There was no financial compensation offered. Diversity in age of enrollment and availability of unschooled children at successive ages enabled a study of the independent effects of chronological and educational age. In Table 1 the composition of the sample in terms of chronological age and amount of schooling across the three-year interval is presented.

Table 1

Number of Children by Age Cohort and Years of Schooling in between Time Points.

Age at T2	Years of schooling in between T1 and T2					Total
	None	1	2	3	4	
9	1	1	10	18	3	33
10	5	3	10	19	3	40
11	9	5	20	19	2	55
12	19	17	9	13	5	63
Total	34	26	49	69	13	191

Instruments

Tests from five distinct domains were selected or developed to measure implicit and explicit representations. These domains were derived from Carroll's (1993) structural model of human cognitive abilities. This model is based on the re-analysis and integration of over 460 data sets found in the factor-analytic literature. In the model, domains of reasoning, verbal learning, memory and others are placed at an intermediate level between more specific measures and psychometric *g*. The domains we selected were: Mathematics, Spatial Integration, Reasoning, Short Term Memory, and Broad Retrieval. For each domain a regular formal test and a more localized test with local stimuli were designed, thus making a total of ten tests. Together with a biographical questionnaire, this battery was administered twice to all children.

Implicit representation

Tests for implicit representation reflect children's facility in realizing that a series of autonomous elements relate to each other in a concrete way. We selected three domains: Mathematics, Spatial Integration, and Reasoning.

Mathematics. Children were asked eighteen mathematical questions. Nine questions were asked in school style (e.g., "How much is two plus two?"). The same nine questions were also embedded in stories (e.g., "Sawita saw two birds this morning and two this

afternoon. How many birds did she see today?"). The eighteen test items consisted of six additions, six subtractions, and six multiplications. All items were open-ended and scored as either correct or incorrect. The eighteen items were summed up into one total score. Internal consistency, calculated across all eighteen items was .92 at T1 and .87 at T2.

Spatial Integration. Two tests were used to measure Spatial Integration. One of them consisted of drawings that depicted three pots, eight faces and seventeen birds respectively. These were presented to children who were asked to count the number of objects in each of drawing. The three items were scored as either correct or incorrect. The second test consisted of six search items. The layout of these items involved a large square drawn on a paper within which twenty figures from four categories were depicted. The figures within a category were only slightly different from each other. Below each square a row of four figures, one figure from each category, was shown. After three items a new set replaced the first set. The first set consisted of geometric figures such as squares and triangles; the second set consisted of concrete figures such as parrots and umbrellas. The children had to look up and point at the figures in the square that matched the ones in the row beneath the square. The first figure of each set was used as an example, thus making six items. The overall Spatial Integration score at each time was obtained by summing up the standardized scores of both tests. Internal consistency, calculated across all nine Spatial Integration items, was .63 at T1 and .32 at T2.

Reasoning. Reasoning was measured with two tests. First, inductive reasoning was measured with Raven Colored Progressive Matrices. It was chosen here because of its appropriateness in cultures for research with participants who are unfamiliar with the more abstract format of the Standard Version. The Colored Version includes 36 matrices arranged in three sets of twelve matrices in varying level of difficulty. For our purpose, a shortened version with two example matrices and eighteen scored matrices was employed. The number of items was reduced as the pilot study showed that the administration of more than twenty matrices decreased the motivation of the children which carried over to later tests. Second, everyday reasoning was measured by four items adapted from Sternberg and Kalmar's (1998) set of computerized items that deal with state changes of objects. The original items involve objects in particular states and the subjects have to

predict the future state of that object or postdict its past state by choosing one of the three displayed states on a computer screen. The four adapted items used small but concrete models of real-life objects familiar to the children in this cultural setting: (1) What will be the length of this girl in two years from now? (2) What will be the level of water in this bottle in one month from now? (3) What was the color of this yellow leaf three days ago? (4) What will be the length of this tree in ten years from now? Children could choose from three different alternatives. The overall reasoning score at each time was constructed by summing up the standardized scores of both tests. Internal consistency, calculated across all 22 reasoning items, was .71 at T1 and .59 at T2.

Explicit representation

Tests for explicit representation reflect children's facility in realizing that a series of autonomous objects differ in very concrete ways. We selected two domains: Short Term Memory and Broad Retrieval.

Short Term Memory. The memory test consisted of two sets. In the first set, twelve words were read slowly in a random order after which the child was asked to recall the words. The words came from four categories of three words each: food, beauty products, tools, and animals. The second set followed the same principle, but now with twelve concrete objects from the same categories as the words. The objects were taken out randomly from a bag and put in front of the child. After the last object was shown the objects were covered with a towel and the child was asked to recall the objects. All correctly recalled words and objects were scored as "one" and the missing as "zero". Internal consistency, calculated across the two memory items, was .57 at T1 and .45 at T2.

Broad Retrieval. Two tests were used to measure Broad Retrieval. First, fourteen pictures were selected from the locally available child posters to form a localized naming test. When an object was named correctly, two points were given; when the response was incorrect, but fell in the same category (e.g., naming a melon an orange) one point was given; in other cases no points were given. Second, children were asked to enumerate as many objects as possible from three different categories: things to eat, animals, and boys' and girls' names. The number of distinct objects given in each category was summed up to a total score. The Broad Retrieval score was constructed by summing up the standardized

Table 2

Contact and Affluence Factor Loadings of Socioeconomic Family Characteristics.

	Contact	Affluence
Father's education in years	.40	
Amount of land owned	-.75	.34
Months of wage employment	.85	
Number of cows owned		.61
Total size of household	.31	.72
Ownership of radio (Yes/No)		.66
Eigenvalue	1.54	1.47
Proportion explained variance	.26	.24

scores of both tests. Internal consistency, calculated across all fifteen Broad Retrieval items, was .33 at T1 and .57 at T2.

Biographical Questionnaire

A questionnaire was administered to assess several socioeconomic and family characteristics, including the educational level of the parents, the number of siblings, and the number of livestock the father owned. An exploratory factor analysis was employed to test the dimensionality of the six socioeconomic indicators. Examination of the screeplot indicated that a two-factor solution gave the best fit. In Table 2 the factor-loadings of the six indicators are shown. The first factor could be understood as "Contact". Indicators of the number of months per year that the father is wage employed and the fathers' years of schooling reflect the amount of contact that the fathers had outside their villages and the extent of exposure they had to a different lifestyle, while the amount of land the fathers owned would tie them to their villages and hinder outside contact. The second factor could be interpreted as "Affluence". Cows are important indicators of status in the rural area where the study took place and together with the size of the household (not just children

but also the larger family) and ownership of electronic equipment such as a radio reflect direct material wealth.

Procedure

All 191 children were tested twice. The first test administration took place during a period of five weeks between November and December 2001. The second test administration took place during another five-week period in January and February 2005. The tests were administered individually in the following order: Reasoning, Broad Retrieval, Spatial Integration, Short Term Memory, and Mathematics. Administration of tests to each child took approximately an hour. Children were tested in a secluded area (mostly a courtyard) in their village that was especially assigned for the purpose. Nevertheless, the testing conditions were often not ideal, since the control on distracting noise from other villagers, heat or fierce light was not optimal. Each child was tested on both occasions by the same experimenter (one of three). All three experimenters belonged to the local community and already had good experience of test administration. All had ten years of schooling and worked as primary school teacher in their own village. So, the experimenters were well known to the children and their cultural practices. This acquaintance may have helped to reduce test anxiety in the participating children. On both occasions, the three experimenters received training prior to testing.

Results

The psychometric properties of the measures are described first. This is followed by an examination of intertest covariances using structural equation modeling to determine the structural properties of the test battery, both for the performances at T1 and T2 combined in a single model, followed by a modeling of the differences in performance between T1 and T2. Finally, the impact of chronological age and educational age on the difference scores between T1 and T2 is examined. This is done in two ways: The regression coefficients of the two occasions are examined in a single path analysis while the per-year increments of each variable are examined by means of several analyses of covariance.

Table 3

Unstandardized Means and Standard Deviations per Domain and Year.

	Maximum score	T1		T2	
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Mathematics	18	9.65	5.19	14.29	3.40
Spatial Integration	9	6.08	2.04	6.72	1.39
Reasoning	22	11.54	3.41	15.04	2.66
Short Term Memory	24	14.17	3.12	16.28	2.60
Broad Retrieval	76 ^a	48.70	9.71	59.04	7.71

^aThe number does not reflect the total number of items, but the best performance observed.**Psychometric Properties**

Table 3 presents the unstandardized means and standard deviations for the five tested cognitive domains at the first and second time point. A preliminary analysis supported the adequacy of the measures in that all performances were well above chance level and, none of the domains showed any ceiling effect, neither at T1, nor at T2. Furthermore, we tested whether sample confounds threatened the design of the study. Table 4 shows the relevant correlations between the predictor and background variables. No serious bias was created by Contact and Affluence. Interestingly, there seems to be an interaction between age and gender. Boys enrolled at earlier ages in school, probably meaning that parents appear reluctant to send their daughters to school at younger ages. It can be concluded that the correlation between age and school attendance at T1 (which was already much lower than is typically found in developed countries) disappears altogether at T2; yet, there is a small gender bias.

Structural properties

Two path analyses were employed to test the stability and change in the cohesion of the implicit and explicit representations, one to capture the performances at T1 and T2 by a

Table 4

Correlations among Predictor and Background Variables.

	Contact	Affluence	Gender	Age at T2
Schooling at T1	.07	.06	.03	.48**
Schooling at T2	-.01	.11	.16*	.10
Schooling T2-T1	-.07	.13	.20**	-.34**
Age at T2	.04	-.00	.05	
Gender (Girls = 0; Boys = 1)	.07	-.01		

* $p < .05$. ** $p < .01$.

single model and another to capture the differences in performance between T1 and T2.

Overall model. We conceptualized a model with Mathematics, Spatial Integration, and Reasoning forming a cluster of implicit representation and with Short Term Memory and Broad Retrieval forming a cluster of explicit representation. Together, implicit and explicit representation make up a dyad, with implicit representation as the more general cluster that influences explicit representation. This precedence of implicit representation is expected to be stable across T1 and T2. Representation at T1 is expected to predict the developmental level at T2. So, we expect a sequence of implicit representation at T1, explicit representation at T1, implicit representation at T2, and explicit representation at T2, in which earlier constructs influence all later constructs. Paths originating from implicit and explicit representations at T1 link to implicit and explicit representations at T2. Four paths are modeled: one from implicit at T1 to implicit at T2, one from explicit at T1 to explicit at T2, one from implicit at T1 to explicit at T2, and one from explicit at T1 to implicit at T2.

Figure 1 shows the best fitting overall model from the path analysis. Performance at T1 is shown on the left, with performance at T2 on the right. The model showed a good fit: $\chi^2(31, N = 191) = 46.21, p = .04$, CMIN/df = 1.49, AGFI = .92, TLI = .97, RMSEA = .05. All displayed coefficients differed significantly from zero ($p < .01$). Paths from implicit at

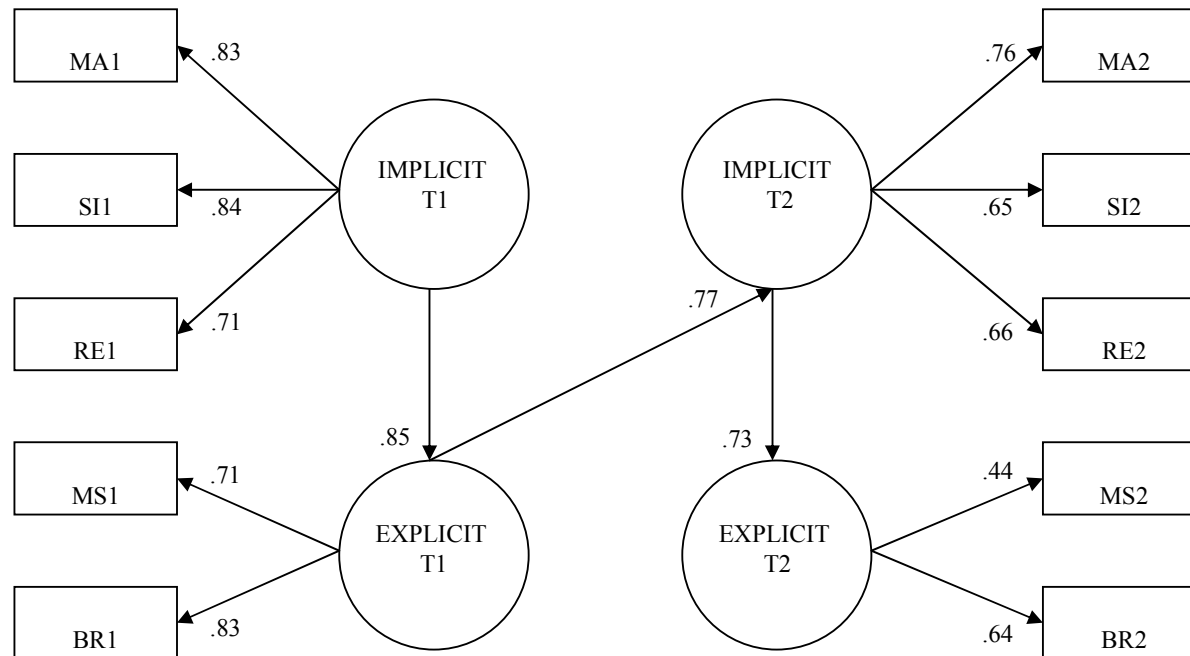


Figure 1. Path model of the hierarchical arrangement of the implicit and explicit representation across T1 and T2, standardized solution. Labels are affixed 1 for T1 and 2 for T2, MA for Mathematics, SI for Spatial Integration, RE for Reasoning, MS for Memory Span, and BR for Broad Retrieval.

T1 to implicit at T2, from explicit to T1 to explicit at T2, and from implicit at T1 to explicit at T2 were not significant. So, representations at T1 and T2 are only connected through the one path from explicit at T1 to implicit at T2. Structurally, performances at T2 show the same underlying pattern as the performances at T1. Implicit and explicit representation hold together very strong at T1, $\beta = .85$, $p < .001$, and at T2, $\beta = .73$, $p < .001$. Bootstrap analysis showed that these values are well within each other's confidence intervals (.80 to .92 for T1 and .48 to .95 for T2), which indicates that the paths did not differ significantly from each other, even though the model fit became somewhat worse when both paths were constrained to be equal. Where the cohesion of implicit and explicit representation only diminished slightly, the decrease of the cohesion seemed to be more of a general pattern, because the factor loadings of the observed scores on the implicit and explicit clusters are smaller for T2 than for T1. This best fitting model excludes direct arrows between implicit representation at T1 and T2 and between explicit representation at T1 and T2. The growth in the implicit representation at T2 is thus not a simple strengthening of components that already existed at T1, but appears to reflect the addition of newly acquired implicit components that were derived from the explicit representation at T1.

Differences model. A structure similar to the basic model of T1 and T2 was also thought to underlie the differences in test scores between T1 and T2. All differences in Mathematics, Spatial Integration, and Reasoning formed a single cluster of change in implicit representation, labeled differentiation, and all differences in Short Term Memory and Broad Retrieval formed a cluster of change in explicit representation, labeled actualization. Figure 2 shows the model. This model shows an excellent fit to the data: $\chi^2(4, N = 191) = 6.41$, $p = .17$, $\text{CMIN}/df = 1.60$, $\text{AGFI} = .95$, $\text{TLI} = .95$, $\text{RMSEA} = .06$. All coefficients differed significantly from zero ($p < .01$). The factor loadings range from .38 to .73, showing that the clusters are well defined. The presence of the two strong clusters of growth shows that difference in performance between T1 and T2 are best explained by two related mechanisms of development and not by just a single mechanism of development. There is a significant path from implicit to explicit representation, $\beta = .49$, $p < .001$, which supports our view that growth in the implicit representation precedes and

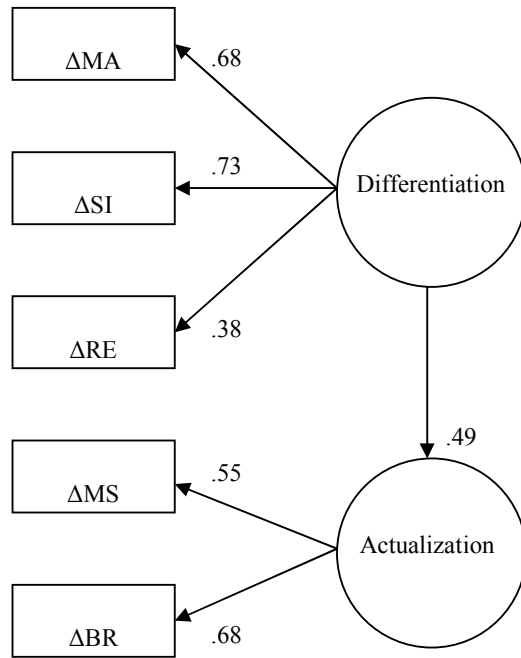


Figure 2. Path model of the two hierarchically arranged latent growth patterns across the five observed growth scores (standardized solution). *Notes.* Measures labels are affixed with Δ to indicate the growth scores from T1 to T2; MA stands for Mathematics, SI for Spatial Integration, RE for Reasoning, MS for Memory Span and BR for Broad Retrieval.

contributes to growth in the explicit representation.

Effects of age

Two statistical methods were employed to examine the impact of chronological and educational age. First, a path analysis was used to study how both ages are related with the performance clusters from Figure 2. Second, a series of analyses of covariance is used to

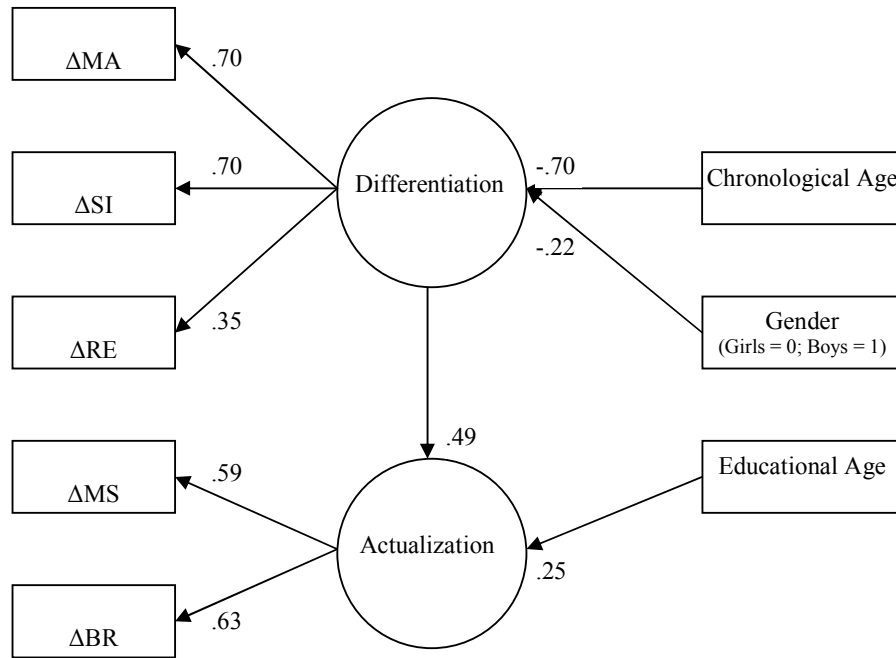


Figure 3. Path model of the regression of three observed indicators on the hierarchically arranged latent growth patterns (standardized solution). *Notes.* Measures labels are affixed with Δ to indicate the growth scores from T1 to T2; MA stands for Mathematics, SI for Spatial Integration, RE for Reasoning, MS for Memory Span and BR for Broad Retrieval.

look more closely at the amounts of development per year of each variable.

Path analysis. As starting point, the model of Figure 2 was used. Chronological and educational age were introduced in this model as predictors of the latent variables, differentiation and actualization. The degree of differentiation is expected to decrease with chronological age and the degree of actualization is expected to increase with educational age. Gender is introduced as an additional predictor, because there was a confounding of

gender and amount of schooling in between T1 and T2, as argued before. The estimated parameters are presented in Figure 3. The model showed an excellent fit to the data: $\chi^2(18, N = 191) = 28.33, p = .06$, CMIN/ $df = 1.57$, AGFI = .93, TLI = .93, RMSEA = .06; all coefficients differed significantly from zero ($p < .01$). Visual inspection shows that the factor loadings are almost similar to those presented in Figure 2. The same is true for the link from differentiation to actualization. The path from chronological age to differentiation is significantly negative, $\beta = -.70$. Thus, development slows down with chronological age. Gender also affected differentiation negatively, $\beta = -.22$. It appears that the development from T1 to T2 seems to slow down faster for boys than it does for girls; girls catch up with boys. Educational age had a positive and significant effect on actualization, $\beta = .25$. Thus, development of explicit representations speeds up as children stay in school for more years.

Covariance analysis. Table 5 presents the effect sizes to measure change from T1 to T2 separately for each cognitive domain and per year of chronological age or educational age. For chronological age, the effect sizes were calculated per age cohort by subtracting for each cohort the means of T1 from the means of T2 and divide them by their pooled standard deviations (Cohen, 1988). For educational age, children with the same amount of schooling between T1 and T2 were grouped together. The effect sizes for each group were calculated as the means of T2 minus the means of T1, divided by their pooled standard deviations. Adjusted means for both ages were generated by analyses of covariance. In the first, chronological age was the grouping variable and educational age the covariate, while in the second, educational age was the grouping variable and chronological age the covariate. This computation of adjusted means is necessary for confining all differences in means to their grouping variable without confounding of the covariate. The results in Table 5 show a consistent picture. The effect of chronological age was largest in the youngest cohort and became gradually smaller in subsequent cohorts, whereas educational age revealed the reverse pattern. It can be concluded that both gain analyses pointed in the same direction of a decreasing influence of chronological age and an increasing influence of educational age on representational development.

Table 5

Effect-Sizes of the Observed Performance Increases by Age Cohort and Years of Schooling, plus the Overall Effect Size (Corrected for Sample Dependence).

	Age Cohort (age at T1) ^a				Years of Schooling ^b				Overall
	6	7	8	9	1	2	3	4	
Mathematics	1.58	1.30	1.10	0.51	0.63	1.13	1.05	1.01	0.92
Spatial Integration	1.22	0.81	0.17	-0.08	0.16	0.40	0.48	0.71	0.40
Reasoning	1.32	0.97	0.84	0.64	0.77	0.59	1.12	1.10	0.87
Short Term Memory	1.06	0.77	0.54	0.27	0.20	0.43	0.99	1.23	0.58
Broad Retrieval	1.62	1.20	0.74	0.83	0.53	0.88	1.20	1.10	0.98
M	1.36	1.01	0.68	0.43	0.46	0.69	0.97	1.03	0.75

^a School cohort effects are eliminated by assigning children at both T1 and T2 the amount of schooling they had in between T1 and T2 and by using these values as covariates in a Repeated Measures ANOVA. ^b Age cohort effects are eliminated by assigning children at both T1 and T2 the age they had at T2 and using these values as covariates in a Repeated Measures ANOVA.

Discussion

The findings from the present study reveal the usefulness of disentangling chronological and educational age for the study of representational development. We conducted a two-wave longitudinal study to examine the interaction between chronological and educational age. The research of schooling effects among the Kharwar provided a natural experiment to distinguish between the effects of both ages. Children with ages ranging from 6 to 9 years at T1 and being either unschooled, drop-out, or attending school, were split into groups. Socioeconomic status did not confound the correlation between chronological and educational age, which was low in the present study. Tests that measured implicit and explicit representation were administered twice with an interval of three years. A number of results emerged that would not have been evident by maximizing the effects of either chronological age or educational age, as we discuss now.

There were three results that carry conceptual implications. First, in line with our expectations, we found that chronological age is more strongly related to the development of implicit representations and educational age is more strongly related to the development of explicit representations. Chronological age had a decreasing impact on representational development, whereas educational age became more important with increasing education. Our analyses of the changes per year supported a similar picture. The effects of chronological age suggest a pattern of diminished growth with age in middle childhood. So, chronological age is a more important predictor of development for younger children than for older children. The reverse pattern was found for educational age; an additional year of schooling makes a larger difference for children with more previous schooling. This result clearly suggests that the shift from one process of development to another that we hypothesized underlies representational development. New input affects children at the end of middle childhood differently, than it does very young children.

Second, confirmatory analyses of the relations between test scores at T1 and among test scores at T2 revealed a consistent division of representation in two modes. Our analysis of the relations between the differences in tests scores between T1 and T2 showed the same division. Change from T1 to T2 is propelled by the increasingly more precise differentiation of a specific implicit representation from another implicit representation,

but also by the increasingly broader actualization of these implicit representations in different situations, resulting in the growth of children's explicit representation. Remarkably, we did not observe any evidence for direct relations between the implicit representations at T1 and T2 and similarly, between the explicit representations at T1 and T2. Our findings are in line with the discussion of accumulation and replacement models of development by Kail and Ferrer (2007). Intuitively, one would assume that children who display some implicit representation at T1 should still have this exact mode of implicit representation at T2. Kail and Ferrer (2007) oppose this view and demonstrate that in the development of visual matching children do not swamp incorrect responses with correct ones but that incorrect responses are gradually replaced. The absence of direct relations from T1 to T2 as well as the shift in development across chronological and educational age (Fischer & Paré-Blagoev, 2000; Larivée, Normandeau, & Parent, 2000) that we observed in our study seem to be consistent with the replacement model of development.

Third, the comparison of the cohesion between test measures at T1 and the cohesion among test measures at T2 showed that the cohesion lessens with age. Domains that make up implicit representations and domains that make up explicit representations become more separated from each other. This decrease of the cohesion between components of representation supports the view that not all development is explained by just a single process, typically thought to be differentiation, where development moves from particulars to generally more abstract levels of representation (cf. Piaget, 1947/2001), but that representational development is also characterized by a shift from abstract to concrete, in addition to the familiar shift from concrete to abstract: Representational development in school moves from implicit to explicit. Implicit representation at a point in time leads to the addition of explicit elements to that exact concept. Later implicit relations may be inferred from these explicit representations.

A problem of the current study was the low reliability of some instruments, both at T1 and T2. Source of the low reliability is probably the low number of items for some of the instruments; another and possibly more important factor may reside in the less than optimal field conditions under which our measures were administered. Although a new

study would be necessary to get more insight in the background of the low values, we do not think that these values jeopardize the conclusions of the current study. First of all, it is important to notice that the low reliabilities were not related with floor and ceiling effects. In addition, the model fit of all three path models was excellent and the factor loadings of the instruments were substantial; so, the low reliability of the items of some instruments did not have major repercussions for their intercorrelations or the error components in the path analyses.

A shift from categorization to transfer has critical implications for the conceptualization of children's representational development and more in particular, for the ways in which the role of schooling should be understood. Discussions on the effects of schooling and culture usually revolve around hypotheses of precisely why transfer from one property to a second property is constrained when children do not really know the material they work with. Transfer from one property to another involves the inference of procedures, representations, and principles from properties and the subsequent application of these "attributes" to other properties (Barnett & Ceci, 2002). Schematically this looks like the following: property \rightarrow attribute \rightarrow property (Liu, Gelman, & Wellman, 2007). Lack of transfer is typically attributed to problems in the inference of appropriate attributes. Discussions on the relation between transfer and schooling featured prominently in writings by Vygotsky, who claimed that through language or particular sociocultural practices children refine their facility to transfer information (Vygotsky, 1978). Research has led to two main hypotheses. The first is that schooling and culture improve the ease with which children might access constructs and the second is that schooling and culture shape the ways by which children use these constructs in everyday life (Norenzayan & Heine, 2005; Van de Vijver & Leung, 1997). The access hypothesis states that only through highly specific prompts children may gain access to constructs and that not being familiar with those prompts prevents transfer from being possible at all (e.g., Sternberg et al., 2002). In contrast, the usage hypothesis claims that, even with full access, there might be no transfer because the constructs themselves might change from unschooled to schooled child and from one culture to the other (e.g., Olson, 1994).

The findings of the present study suggest a pattern that deviates from the access and the usage hypotheses. Not the inference phase is crucial for transfer, but the prediction phase that follows after such inference. We find that schooling affects this phase and not inference. More recent research supports this view. Children infer the correct personality attributes from properties presented to them, even when they are not able predict other properties from those exact attributes (Liu, Gelman, & Wellman, 2007). Thus, our findings are in line with the idea that children are learning to apply to many different settings the knowledge they already have. This idea echoes Cole and Bruner's plea that researchers in developmental psychology need to invest time in trying to examine how this shift to transfer may be improved, rather than continuing to try and incite new intellectual structures in children (Cole & Bruner, 1971). Enhancing children's explicit representation is the route to take, as it provides children with the details of difference and similarity that stimulates their future transfer. Schooling provides the best opportunity.

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Natural Variation of Typicality in Childhood: Visual Search of Ideals and Features in a Multicultural Context

Studies on the role of typicality in transfer and inductive reasoning often confound typicality with familiarity. This paper reports an experiment on the interaction of familiarity and typicality. A total of 59 Turkish-Dutch and 58 Dutch primary school children (mean age = 11.09 years) completed a 96-item series of visual search tasks, in which they had to see whether a target that was presented to them first, was present in a subsequently presented set of stimuli. Familiarity was manipulated by using both Turkish and Dutch items and typicality was manipulated by varying the salience of the difference between the target and its distractors. Main effects of both familiarity and typicality were not significant, but their interaction was. Low familiarity led to an advantage in the processing of features, a high familiarity to an advantage in the processing of ideals. This effect disappeared when the number of distractors became larger. It is concluded that effects of typicality are restricted to familiar perceptual content.

Most children and adults would consider a book a better example of things that can be read than a TV guide or a drug prescription, but for many other categories the most typical example could be different for people of different ages, different cultural backgrounds, or even for one person in different situations (Barsalou, 1985; Heit & Hahn, 2001; Medin, Ross, Atran, Cox, Coley, Proffitt, & Blok, 2005). Variation in the most representative

member of a category is so widespread that many researchers in the field now claim some form of specificity. The precise nature of such a specificity has been examined extensively over the last few decades (Inagaki & Hatano, 1996, 2002; Jipson & Gelman, 2007; Kemler Nelson, Frankenfield, Morris, & Blair, 2000; Matan & Carey, 2001; Simons & Keil 1995), but the focus in these studies is often on showing that typicality is an important feature of information processing and not on showing the situational changes in what is typical and what not. In the present study we aim to develop a better understanding of the conditions in which typicality might be found. To this end we aim to disentangle typicality from familiarity and task complexity. Stimulus content is varied by selecting pictorial stimuli from Turkish as well as Dutch cultural backgrounds. Exposing Turkish-Dutch bicultural children and Dutch monocultural children to these same stimuli in a visual search task leads to a natural variation in typicality.

To understand typicality, researchers have investigated the defining properties of categories (Barsalou, 1985; Osherson, Smith, Wilkie, Lopez, & Shafir, 1990). One way by which people tend to define categories is by means of central tendency. Another is by means of ideals. Central tendency is a purely cognitive metric of the degree of resemblance between all members that belong to the category. Members that have the most features in common with other members are central to the category, while those members with fewer features in common are less central. The most central members are also the most typical. Ideals relate to the goals people have. One could think of a causal sequence that goes from the cause of a category to the goal that people derive from that one cause and eventually to the ideal that people associate with their goals (Barsalou, 1985). For food, such a cause might be the preparation of an evening meal, with the added goal to lose weight. One ideal for this cause would thus be food items with only a very few calories. For other goals, other ideals might be held, even with a same cause.

Variability in what is typical is an important aspect of the idea of typicality. Ample evidence of the variability of information processing may be gathered from developmental (Fisher & Sloutsky, 2005; Sloutsky & Fisher, 2004) and cross-cultural studies (Bailenson, Shum, Atran, Medin, & Coley, 2002; Choi, Nisbett, & Smith, 1997; Medin, Coley, Storms, & Hays, 2003; Norenzayan, Smith, Kim, & Nisbett, 2002). Microgenetic studies have been

particular effective in showing the within-individual variability of information processing (Siegler, 1994, 2000). Children and adults vary in how they solve related problems, in how they solve the same problem twice, and even in how they solve the same problem within a single trial. For example, Tunteler, Pronk, and Resing (2008) showed two distinct training effects that helped to improve analogical performance in six-year old children, above and beyond a practice effect. Although the specific reasons for this high variability are unclear, research suggests that stimulus familiarity and perceived task complexity contribute to this variability (Heit & Hahn, 2001; Kittur, Holyoak, & Hummel, 2006).

To describe familiarity and complexity as two possible preconditions that might promote or inhibit the differentiation of ideals and features, a connectionist modeling approach is chosen. Connectionist models were originally developed to explain the increasingly higher speed with which children's vocabulary size develops (Elman, Bates, Johnson, Karmiloff-Smith, Parisi, & Plunkett, 1996; Fauconnier & Turner, 1998; Marcus, 1998, 2001; Van Geert, 1991). Separate words or other units of knowledge in people's mental representation connect with other words or units so as to build up an extensive network. In such models the differentiation between ideals and features is brought about by the amount of connections in a network. In richer networks, discrete units of information share more features with other units. As a consequence, the relevance of features becomes smaller with increasing familiarity; relevance shifts to the meaning that is shared between the single elements in one's representation, ideals (Rips, Shoben, & Smith, 1973; Rosch & Mervis, 1975). However, this does not have to mean that for familiar stimuli the ideals are always accessed. Even when stimuli are familiar, having to discriminate a particular target from its distractors might require people to access features instead of ideals (cf. Sperber, Cara, & Girotto, 1995). When many distractors are present, the need to attend to many different elements within the network at the same time is vital for success and accessing the network by way of ideals might become counterproductive (Anderson & Lebiere, 2003; Halford, Wilson, & Phillips, 1998).

Frame switching between the ethnic and mainstream cultural frames by bicultural individuals is a process where situation specific change from ideals to features and back is striking (Benet-Martinez, Lee, & Leu, 2006; Benet-Martínez, Leu, Lee, & Morris, 2002).

Cultural frame switching is a process in which everyday validity and need for transfer coincide. Today many people identify with more than one culture (Berry & Sam, 1996), often their own 'home' culture, the culture from where their family originates, and their 'host' culture, the culture to which they immigrated and continue to live. In their cognitive representation bicultural persons capture cultural knowledge for both the cultures they identify with. Cultural frame switching is a process in which biculturals have to change from one cultural meaning system to the other in response to changing situational demands (Benet-Martínez, Lee, & Leu, 2006; Benet-Martínez, Leu, Lee, & Morris, 2002).

Data were collected amongst both bicultural and monocultural children in The Netherlands. The first wave of immigrants to The Netherlands in the 1960s was formed by migrant workers from the Mediterranean and the former Dutch colonies. At present, 17% of the population is of foreign origin. This figure includes people not born in the Netherlands, as well as those born in the Netherlands with at least one nonnative parent. It is estimated that in 2010, almost half of the population of the three largest cities will consist of migrants (Arends-Tóth & Van de Vijver, 2003). Turkish-Dutch biculturals constitute the largest immigrant group in The Netherlands and they are perceived as the most prototypical of all migrant groups by Dutch monoculturals (Pettigrew, 1998). For this reason, in the present study biculturals were exclusively limited to Turkish-Dutch bicultural children.

The aim of the present study is to gain insight in the different factors that contribute to the ease with which bicultural and monocultural children might distinguish subtle differences in members of the same category of either Dutch or Turkish stimuli. We examined the two-way interaction of typicality and familiarity in four hypotheses: (1) When the content included in the search items is less familiar, bicultural as well as monocultural children process features faster than they process ideals. (2) When item content is familiar, children process ideals faster than features. (3) The interaction of typicality and familiarity is the most salient for the smallest number of distractors and gradually declines when the number of distractors increases. (4) Typicality is item specific and not the consequence of fixed cultural frames. So, for biculturals, processing ideals or features is not related to their level of adaption to Dutch society.

Method

Participants

A sample of 117 primary school children in The Netherlands, ranging in age from 8 to 13 years, took part in the study. Of this total, 59 were of Turkish-Dutch origin (26 boys and 33 girls; mean age is 11.24 years), with 58 of Dutch origin (31 boys and 27 girls; mean age is 10.92 years). Children were recruited in their school. Prior to the data collection, the school boards and all parents with children in grades 6, 7, and 8 were asked written consent. Of the 59 Turkish-Dutch children, 46 had parents who were both born in Turkey and 13 had one parent who was born in Turkey. All Turkish-Dutch children except three were born in The Netherlands. The majority of Turkish-Dutch in our sample went to school at an Islamic school in Rotterdam, while a few other Turkish-Dutch children went to school at two mixed schools in the south of The Netherlands. The Dutch children went to several schools in the south of The Netherlands.

Instruments

Two tests of visual search, one Turkish and one Dutch, were designed to measure response time in telling apart similar items from one category, at two levels of abstraction, features and ideals. The reason for using both Turkish and Dutch items was to manipulate familiarity. The two visual search tests were designed following examples from the visual search literature (Geisler & Chou, 1995; Wolfe & Horowitz, 2004). In addition, a single questionnaire that addressed socioeconomic status as well as acculturative behavior, was administered to all 117 children.

Visual search. Children had to complete two 48-item series in which they had to judge whether the target that was presented to them first could be located among a subsequent set of distractors. Decision time was taken as the measure of children's performance. Items were generated by using five item rules: cultural origins of the target (2 levels), domains (4 levels), typicality (2 levels), presence or absence of the target amongst the distractors (2 levels), and finally the number of distractors (3 levels). This results in 96 items. An initial pool of Dutch and Turkish pictorial stimuli was assembled by way of a web based search. A panel of Turkish, Dutch and Turkish-Dutch experts rated the cultural

typicality of these targets, which led to the identification of specifically Dutch and specifically Turkish target stimuli in four categories: famous persons (e.g., Sinterklaas and Atatürk), delicacies (e.g., Dutch rusk with sprinkles and Turkish baklava), kitchenware (e.g., Dutch cheese slicer and Turkish cezve), and national flags. For each of these targets two times seven distractors were either selected from the initial pool of stimuli or created by using photo editing software. The first seven distractors concerned features and consisted of minor, purely perceptual variations in appearance: changes in the color, size, orientation, or shape for some part of every target. The latter seven distractors concerned ideals and consisted of relational variations in meaning: other members from the same higher order categories. Items were grouped in two 48-item blocks of Dutch and Turkish items. The sequence of the blocks was randomized across children and the items in each block were randomized as well. Internal consistency (based on the decision times) for the 48 Dutch items was .90 for the Dutch children and .93 for Turkish-Dutch children, and for the 48 Turkish items .92 for the Dutch children and .91 for Turkish-Dutch children. For all 96 items the internal consistency was .95 for both groups.

Questionnaire. All 117 children completed a questionnaire that concerned their key demographics. In addition, all Turkish-Dutch children were also asked 21 questions about their acculturation behavior. Five questions concerned their use of language, four questions concerned social behavior, and twelve final questions concerned the frequency with which they were involved in specifically Turkish and Dutch activities.

The items of the questionnaire were clustered with a factor-analysis. Demographic variables were analyzed separately from the acculturation variables as only these five demographic variables were administered to all 117 children. The result was a cluster for mothers' socioeconomic status and a cluster for fathers' socioeconomic status, explaining 57.98 and 31.74 percent of all variance, respectively. These two factors were subjected to one hierarchical factor analysis that explained 56.41 percent of the variance.

The 21 acculturation items administered to the Turkish-Dutch children only were also taken together in a single analysis. This led to four clusters: private adoption, private maintenance, public adoption and public maintenance, explaining 14.83, 14.16, 8.45, and 7.42 percent of the variance. These four clusters were again subjected to one hierarchical

factor analysis that explained 29.98 percent of the variance. Adoption in the private (.31) and public (.75) domains loaded positively on this one factor, whereas maintenance in the private (-.69) and public (-.26) domains loaded negatively on this factor. Following Kagitcibasi (2005), this pattern is interpreted as autonomy orientation.

Procedure

The testing language was Dutch. The tests were individually administered in a quiet and isolated office or class room. The administration took about 30 minutes. All children completed first the search items and then the questionnaire.

The instruments were administered in a standardized manner. First, children were seated behind a table with a notebook that had a 15.4 inch flat screen. Second, all targets were presented one by one on the screen in sizes up to 4 by 4 inch and children were asked whether they thought each target was typically Turkish or typically Dutch. Third, children carried out a trial item together with the test leader and this trial was repeated until the child understood the procedure of each item: (a) the presentation of a focal point at the centre of the screen for 1000 ms; (b) a presentation of the target, on the exact same location as the focal point first was seen, for 1200 ms; (c) a short interspersed of an empty black screen for 850 ms; (d) the appearance of a 3 by 3 matrix with three, five or seven images simultaneously on the screen, one of which could be the previously presented target. Each child received the instruction to decide as fast as possible whether the target was present or absent and respond accordingly. Responses were recorded by means of a response box that was specifically designed for our purposes. The box contains a touch pad as home button and two response buttons, 'yes' or 'no'. Children respond by lifting their finger from the home button (which they had kept there throughout the item sequence) and press "yes" or "no". When children lift the finger from the home button, the screen immediately turns black and decision time is recorded as the time between the onset of the search matrix and their lifting of their finger from the home button. When children press either response button movement time is recorded as the time between the lifting of the finger from the home button and the pressing of the respective response button. When an item was completed, the next item started again by pressing the home button. Children

could pause at any point in between two items and resume when they are ready by placing their finger on the home button. Time-out time was 6 seconds, after which the screen turned black.

Results

The psychometric properties of the cognitive dimensions are described first. This is followed by an examination of the within-subject effects of familiarity and typicality, both with number of distractors as an additional factor in a single analysis and separately for 2, 4, and 6 distractors. Finally, effects of culture are examined by exploring the between-subject effects of culture and the correlations of autonomy with familiarity and typicality for the Turkish-Dutch children.

Psychometric properties

Table 1 shows the unstandardized means and standard deviations for the response times of the total number of items and also for the number correct for ideals, features, Turkish and Dutch items, separately for Turkish-Dutch children and Dutch children. Visual inspection leads to the observation that Dutch children respond a little bit faster than Turkish-Dutch children on all four dimensions. Critical is the observation that children scored about half correct for ideals, features, Turkish items, and Dutch items, which is close to chance level. In order to verify whether this pattern reflects a performance at chance level or hides a more complex pattern of effects, a 2 (Turkish items or Dutch items) \times 4 (famous persons, delicacies, kitchenware, or national flags) \times 2 (ideals or features) \times 2 (presence or absence of the target) \times 3 (2, 4, or 6 distractors) repeated measures analysis of covariance for correctness at item-level was carried out, with culture as between-subject factor and children's socioeconomic status as a covariate so as to reduce bias in the socioeconomic status of Dutch and Turkish-Dutch children. Significant were the main effect of presence or absence of the target and the interaction between typicality and the presence or absence of the target, $F(1, 107) = 8.95, p < .01$, partial eta-squared = .08, and $F(1, 107) = 4.01, p < .05$, partial eta-squared = .04, respectively. When the target is present children score more correct ($M = 6.13$ out of 12) than when the target

Table 1

Overall raw means and standard deviations for response time and number correct, per culture.

	Turkish-Dutch children		Dutch children	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Decision time				
Ideals	1759	388	1647	367
Features	1739	401	1618	362
Turkish	1721	404	1649	409
Dutch	1778	428	1615	352
Number correct				
Ideals	24.35	3.42	23.74	3.35
Features	24.22	3.40	23.24	3.26
Turkish	24.05	3.74	22.71	3.11
Dutch	24.53	3.49	24.28	3.10

is absent ($M = 5.84$ out of 12). This effect is strongest for ideals ($M = 6.29$ for presence; $M = 5.76$ for absent) than for features ($M = 5.96$ for presence; $M = 5.93$ for absent). The main effect of culture was not significant $F(1, 107) = 1.58, p = .21$, partial eta-squared = .02. It turns out that children in our sample did not process the 96 items at random. Differences in processing are now analyzed in more detail by looking at the decision times.

Within-subject effects

The effects of typicality and familiarity were tested in a 3 (2, 4, or 6 distractors) \times 2 (Turkish or Dutch items) \times 2 (ideals or features) repeated measures analysis of covariance, with culture as between-subject factor and children's family socioeconomic status as a covariate, as it might (but necessarily so) reduce bias in the socioeconomic status of Dutch

Table 2

*Estimated Marginal Means (in ms) and Standard Errors for the Effect of Origin by Typicality per Culture.**

		Turkish items		Dutch items	
		<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>
Correct items	Ideals	1748	39	1728	44
	Features	1725	39	1757	44
2 Distractors	Ideals	1842	61	1745	54
	Features	1655	50	1813	58
4 Distractors	Ideals	1720	44	1716	54
	Features	1721	46	1702	52
6 Distractors	Ideals	1759	56	1723	56
	Features	1680	56	1757	56

* All scores are corrected for socioeconomic status. *M* = mean. *SE* = standard error.

and Turkish-Dutch children. Main effects of familiarity and typicality were not significant, $F(1, 107) = 0.12$, $p = .73$, partial eta-squared = .00, and $F(1, 107) = 0.14$, $p = .91$, partial eta-squared = .00, respectively. The effect of the number of distractors was also not significant, $F(2, 106) = 1.25$, $p = .29$, partial eta-squared = .01. In contrast, the interaction of origin with typicality was significant, $F(1, 107) = 4.16$, $p < .05$, partial eta-squared = .04. Table 2 presents the estimated marginal means of the interaction of origin with typicality. For Turkish items features are processed faster than ideals. For Dutch items the ideals are processed faster than the features. This confirms our first two hypotheses.

The interaction of familiarity with typicality was also explored separately for number of distractors as the three-way interaction of number of distractors, familiarity, and typicality in this main analysis was small but still significant, $F(2, 106) = 3.31$, $p < .05$, partial eta-squared = .03. The interaction of familiarity with typicality was highly

significant when 2 distractors were presented, $F(1, 107) = 9.31, p < .01$, partial eta-squared = .08. This effect was not present with 4 and 6 distractors, $F(1, 107) = 0.12, p = .73$, partial eta-squared = .00, and $F(1, 107) = 2.07, p = .15$, partial eta-squared = .02, respectively. This confirms our third hypothesis, which stated that the effect of typicality disappears when processing becomes more effortful.

Cultural effects

No main effects of culture reached significance in our sample, indicating there were no differences in decision time (DT) between Turkish-Dutch and Dutch children. Not one interaction between culture and familiarity was significant. The only significant interaction of culture was with typicality and only with 4 distractors, $F(1, 107) = 4.00, p < .05$, partial eta-squared = .04. Turkish-Dutch children were faster with features (DT = 1734 ms) than with ideals (DT = 1822 ms), whereas Dutch children were faster with ideals (DT = 1614 ms) than with features (DT = 1689 ms). It is not clear why this effect is only present for 4 distractors and not for 2 or 6 distractors.

Correlations between the autonomy orientation of children's family and the differences in decision time between ideals and features were also examined, for Turkish-Dutch children only, separately for number of distractors. With 2 distractors, correlations between autonomy and differences in DT between ideals and features are not significant for Turkish and Dutch items, $r(51) = .18, p = .20$, and $r(51) = .18, p = .22$, respectively. With 4 distractors, these two correlations are even smaller, $r(51) = -.05, p = .73$, and $r(51) = -.01, p = .94$, respectively. In contrast, with 6 distractors both of these correlations become significant, $r(51) = .40, p < .01$ and $r(51) = .38, p < .01$, respectively. The relations between culture, acculturation, and performance on these visual search tasks are not consistent. Results with regard to the fourth hypothesis are inconclusive.

Discussion

Aim of the present study was to develop a more informed idea of the conditions in which effects of typicality arise. In order to achieve this aim we attempted to disentangle typicality from familiarity and task complexity. We conducted an experiment of response

time in visual search amongst monocultural and bicultural children in the Netherlands to examine the interaction of familiarity and typicality. Involving both monocultural and bicultural children allowed us to manipulate familiarity independently of typicality, while remaining close to the everyday experience of children: We used naturally occurring stimuli instead of nonsense stimuli, which are so often used in experiments of transfer and inductive reasoning. A number of results emerged that would not have been evident when looking at typicality alone, as we discuss now.

There were three results that have conceptual implications. First, while familiarity and typicality do not have significant main effects, their interaction is significant. Dutch monocultural as well as Turkish-Dutch bicultural children process features faster than ideals for unfamiliar items; however, we find the opposite for familiar items: Dutch monocultural as well as Turkish-Dutch bicultural children process ideals faster than features. This finding implies that the independent manipulation of typicality and familiarity in our experiment was not matched by a similar independence in the responses; typicality and familiarity are dependent. Our results suggest that typicality only becomes important with familiar items. The dependence of typicality on familiarity may explain why these two features were often confounded in previous studies.

Second, the size of the interaction between familiarity and typicality depends on the number of distractors. The interaction between familiarity and typicality is largest in items with two distractors, but is nearly absent in items with four and six distractors. This finding questions the automatic access of either ideals or either features. Instead, our results suggest that also when perceiving familiar stimuli, the need to discriminate a particular target from its distractors requires the access of features and that the access of ideals might actually impede success. The distinction in ways in which features and ideals are processed loses much of its relevance in everyday perception, because common perceptual tasks often require both types of processing.

Third, this observed interaction between familiarity and typicality is not systematically related to children's cultural membership or Turkish-Dutch children's acculturative status. Cultural membership did affect visual search only at one complexity level; acculturative status had an influence on another complexity level. It can be

concluded that processing in the present study is not guided by cultural frames. The Turkish stimuli might have been insufficiently unfamiliar to both Dutch and Turkish-Dutch children to make the subtle discriminations required in the present study. Culture might contribute more when the cultural distance between the two groups would have been larger and when the stimuli used would have tapped into more culture-specific knowledge. Future research should explore this specificity issue in more detail.

The generalizability of the present findings requires some closer examination. The average performance level of the children was relatively low. It could well be that stronger interactions between familiarity and typicality and indeed main effects of familiarity and typicality would be found when the perceptual tasks would be simpler. Nevertheless, the present data did show high alpha levels for decision times of the Turkish and Dutch scales and on top of this a significant interaction between typicality and familiarity. Moreover, analyses not reported here revealed that incorrect items showed the same patterns of effects as correct items (i.e., an interaction of familiarity and typicality). Future studies should see whether the interaction of familiarity and typicality is also found for simpler tasks. Effects of acculturation might be more pronounced for simpler stimuli.

Another generalization issue involves the choice of content domains. In the present study we looked at content that might be considered cultural artifacts: famous persons, delicacies, kitchenware and national flags (Bloom, 1996). The domain of artifacts is typically contrasted with the domain of living kinds and the domain of behavior (Gelman, 2003; Keil, 2003). Typicality in the domain of living kinds is strong (Atran, 1998) and young children recognize that artifacts are fundamentally different from living kinds (Jipson & Geman, 2007). Thus, the interaction between typicality and familiarity we find in this present study may not generalize to domains like living kinds or theory of mind. Nevertheless, artifacts are a domain that children meet frequently in their everyday lives and our findings are likely to generalize to much of children's everyday experience.

A final generalization issue refers to the nature of the visual search task employed in the present study. Our tasks present children with conflicting images in the search matrix that are intended to distract from the targets. The use of distractors in the present study deviates from the typical practice. Studies of transfer use the same task format to

measure typicality in transfer, with minimal variations. For example, “Trout are a type of fish: All trouts have heglal inside:: Do all fish have heglal inside?” Items such as these vary the extent to which the premise category is typical of the conclusion category, in the above example thus how typical trout is of fish. It might be that some people find that salmon is more typical of fish, or tuna is, and this may influence the inferences people make. Nevertheless, the present study employed a task that omits the inference phase in property to property transfer and still observed that an effect of typicality remains firmly present.

The interaction of familiarity and typicality in this research has critical implications for the conceptualization of age-related and cross-cultural differences in the categorization of artifacts. Often researchers argue for a high specificity of ideals and features, across age as well as culture. This specificity is typically attributed to the inference phase of transfer. Transfer from one property to another, involves the inference of a attribute from the first property and the subsequent application of the attributes to other properties (Barnett & Ceci, 2002). Schematically this resembles a fixed sequence: property → attribute → property (Liu, Gelman, & Wellman, 2007). Our findings also raise the issue of how transfer in childhood may be improved. In Brouwers, Mishra, and Van de Vijver (2008), we follow Cole and Bruner (1971) by arguing that researchers need to invest their time by trying to determine how transfer may be improved, rather than continuing to try and incite intellectual structures in children. In the present study we find that familiarity with relevant everyday properties affects the processing of information in a positive way. The causes of high variability in such familiarity require further investigation.

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Discussion

The shared aim of the four studies in this dissertation was to develop a more informed understanding of the link between culture and cognition. Context specificity is an important element of cognitive transfer, but how specificity actually transpires is subject of much discussion. Aim of the present dissertation was to find support for the hypothesis that success and failure of transfer should be attributed to children's mental representation. In order to achieve this aim I conducted studies at the four lower levels of Cole's (1996) model of the distribution of cognition in time: the history of human beings on earth (cultural-historical time), the history of the individual's immediate context (ontogeny of the outside), life of the individual himself or herself (ontogeny), and the history of moment-to-moment lived experience (microgenesis). A number of results would not have been evident when examining specific aspects of cognitive functioning in isolation, as we discuss now.

Each of the four studies yielded results with conceptual implications. First, our analysis of cognitive functioning from a cultural-historical perspective found three important factors to be independently associated with an increase in Raven scores: educational permeation, educational age, and publication year. Two of these factors, educational permeation and educational age, will often act in concert; economic growth over an extended period of time will usually lead to more educational permeation and to an increase of the average educational age of a population. If the Flynn effect is observed in a country with a substantial economic development in the period we studied, the size of the Flynn effect seems to be boosted by the economic development. Raven scores should thus not be interpreted from just an individual-level perspective. We found that test and country characteristics are also important. The Raven's test, as many other tests, may contain elements that show differential suitability across cultures (Van de Vijver, 1997). Our analysis of cognitive functioning at a cultural-historical level of change supports this perspective.

The nature of the Flynn effect has attracted several different interpretations. Central issue in these interpretations is often whether the rise in Raven performance reflects an actual rise in intelligence or whether other factors also play a role. Some of the factors that are suggested are improved nutrition, quality of schooling, and smaller families (Flynn, 2007). What these interpretations have in common is that they are rather distal to the actual changes that take place in children's or adult's cognitive processing. This questions the applicability of many of the large analyses to explain the mechanisms underneath the Flynn effect. Small scale studies that are more proximal to the true cognitive transformations will be necessary to shed light on the mechanisms that produce the change that is observed.

Second, an analysis of cognitive functioning from an ontogenetic between-child perspective among schooled and unschooled Kharwar children in India found a superior test performance of school-attending children in six-year olds. However, this higher performance of school-attending children should not be taken to imply that they think in a way that is qualitatively different from the way in which unschooled children tend to think. Standardization on either chronological age or educational age yielded similar factor structures, suggesting that there are no major qualitative differences between school-attending and unschooled children in cognitive functioning in our sample. Using a design that allowed for a direct comparison of educational age and chronological age, we found that school attendance has a substantially smaller impact on children's competence than natural stimulation provided by everyday life. On average, the increase caused by one year of chronological age is twice the increase caused by one year of schooling. Moreover, schooling effects on tests of cognitive ability are confined to those cognitive domains that are somewhat removed from basic operativity and that primarily benefit from the knowledge of factual details (Ceci, 1990). However, the generalizability of the present findings requires closer examination, as the overall quality of the schools in our study was rather poor. It could well be that a higher quality in the schools might have induced stronger school effects (Fuller & Clark, 1994).

Third, our analysis of cognitive developmental processes from an ontogenetic within-child perspective among the same schooled and unschooled Kharwar children in

India as in the second study saw that chronological age had a decreasing impact on representational development when children became older and that educational age became more important with increasing amounts of schooling. Thus, chronological age is a more important predictor of development for younger children than for older children. The reverse pattern was found for educational age; an additional year of schooling makes a larger difference for children with more previous schooling. New input affects children at the end of middle childhood differently, than it does very young children. This changing pattern of the relevance of developmental processes is reflected in a consistent division of representation into two modes. Cognitive change in primary school age is propelled by the increasingly precise differentiation of specific implicit representation from other implicit representations, but also by the increasingly broader actualization of the implicit representations to different situations, thus resulting in the growth of children's explicit representation (Karmiloff-Smith, 1992).

Fourth, the analysis of cognitive functioning from a microgenetic within-child perspective among Dutch monocultural and Turkish-Dutch bicultural children found a significant interaction of familiarity and typicality, while their main effects were not significant. Dutch monocultural as well as Turkish-Dutch bicultural children process features faster than ideals for unfamiliar items. However, we found the opposite for familiar items: Dutch monocultural as well as Turkish-Dutch bicultural children process ideals faster than features. Such a finding implies that the independent manipulation of typicality and familiarity was not reflected in an independence of the responses; typicality and familiarity are dependent. Our results show that typicality only becomes important with familiar items. The dependence of typicality on familiarity can explain why these two facets are often confounded in earlier studies. In addition, the size of the interaction between familiarity and typicality depends on the number of distractors. The interaction between familiarity and typicality is largest in items with just two distractors, but nearly absent in items with four and six distractors. These findings question the automatic access of either ideals or either features (Heit & Hahn, 2001). Instead, our findings suggest that when perceiving familiar stimuli typicality may arise when there is not a need to discriminate one particular target from many distractors.

Differences in how mental representation affects performance are manifest in all four studies. A Flynn effect is the result of schooling and a richer context passing on more information and stimulation to mental representations. Variation in the size of the country specific Flynn effects may then be attributed to the degree to which representations of their citizens are enriched over successive generations. The difference between chronological and educational age can be explained by a sharp conceptual distinction between the degree to which a domain in a mental representations is differentiated from other domains and how rich that one domain is. Children that attend school may perform better than children who do not attend school, but this only reflects the richness of particular domains in their mental representations and not the existence of domains as such. This is in line with a decrease in the effect of chronological age, which reveals that domains reach a maximum in their differentiation, and an increase in the true effect of educational age, which reveals that new input is more readily accepted into the network when the network is already richer. The distinction between ideals and features derives from their familiarity and again shows the central role of mental representation.

Dynamic variation at the four scales of distribution of cognition that were examined in my dissertation (the variation in the size of the Flynn effect across countries with differences in affluence; unique effects of chronological and educational age; distinct patterns of change across chronological age and educational age; and the conditionality of typicality) has implications for the conceptualization of culture and cognition. The findings support the hypothesis that the differences in cognitive functioning between children and adults from different cultures are best explained by differences in mental representation. In richer representations, discrete units of information share more features with other units, thus familiarity with relevant everyday properties affects the processing of information in a positive way.

Representation and transfer

One implication that follows from the finding that mental representation explains developmental change and cross-cultural differences is that human information processing is neither domain nor situation-specific, but something that we might call representation-

specific. The implication is that knowledge may be mentally transferred from one domain to the other and from one situation to the other, when the actor explicitly represents the conditions of each domain or each situation and is able to connect the different conditions to one another. In other words: Context itself should be mentally represented in order for cognitive transfer to transpire. The central position of mental representation in information processing does not discard the autonomy of both domains (Gelman, 2003) and situations (Barsalou, 1985; Shore, 1996), but does suggest that domains may associate with other domains and that situations may associate with other situations, depending on the specific unit of information in the actor's mental representation that is accessed.

At first sight the psychological literature appears reluctant to accept the idea that autonomous domains may associate on occasion and that the same is true for autonomous situations, but a closer examination of the literature reveals that the idea of representation directed association is not outside the accepted breadth of information processing. Rather than being reluctant to accept that different domains and situations may associate, it seems that domain-specificity is often addressed in different areas of the literature than situation-specificity and that their mutual relevance tends to go unnoticed. On the one hand, the literature appears to be divided on how mental representation is thought to be connected to reality. In the representation of a math problem or a game such as the Tower of Hanoi the connection with reality is thought to be strong (Newell & Simon, 1972), while in the use of heuristics the connection is thought to be weak (Gigerenzer, Todd, & The ABC Research Group, 1999). On the other hand, the literature appears to be divided on how cohesive the elements of mental representations are. In representations such as crystallized intelligence (Mackintosh, 1998) and grammar (Pinker, 1994) the constituent elements are thought to be highly cohesive, while in preconceptions about how the social biological, and physical worlds work (cf. Richerson & Boyd, 2005) constituent elements are thought to be not very cohesive.

In order to examine this discussion in more detail I juxtapose the two dimensions to create four different perspectives, as shown in Figure 1. The four poles resemble high cohesion (*molar*), no cohesion (*molecular*), a connection that is *dictated* by reality, and a connection that is *mediated* by a lens or filter. The first cell captures the idea that each

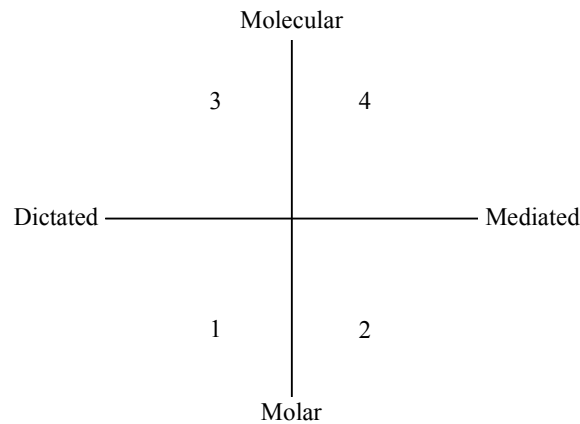


Figure 1. Model that captures two axes that relate four major conceptual frameworks in psychology that deal with mental representation.

cognitive representation is an incomplete reflection of a particular event, entity, and operation that gradually develops to become more abstract, while becoming more detached of its constituent details. A recent empirical example espousing this view is given by Siegler (1999). The author has demonstrated that children's mathematical skills develop through the discovery of new processing strategies, in addition to the continuously changing frequency with which they use familiar strategies and. Every new strategy is an extension and simplification of previous strategies and fits precisely among the ones learned earlier, because all relations amongst features are dictated by the fundamental nature of things and representations follow those relations.

Many theorists now see that children and adults exhibit much more variation in their cognitive functioning than classic theories such as those by Piaget (1947/2001) can explain and for this reason have started to formulate newer frameworks. These attempts tend to take two directions and are found in cells two and three. Cell two captures the idea that representations will eventually make up a large system, but contends that cohesion among aspects in a representation is facilitated by overt social values and thus not by the

natural relations among features. A recent empirical example espousing this view is given by Benet-Martinez, Lee, and Leu (2006). These authors have shown that Chinese immigrants in the USA develop separate Chinese and American representations and that they switch between the two when necessary. Only valued features are internalized into the representation and others are not. This would imply that representations gradually become unique to one situation, but that they extend across all possible content domains. The fully opposite view is gathered from the third cell, thus that any representation draws from one domain at a time, but that they extend across all possible situations. Here, domains reflect specialized capacity spheres, each with a characteristic set of operations and processes. In this view representations thus mirror the natural relations among features in reality, but do not build into one large system. A recent empirical example espousing this view is given by Demetriou, Kui, Spanoudis, Christou, Kyriakides, and Platsidou (2005). These authors demonstrate that differences between Chinese and Greek children in arithmetical skills are not superficial, but extend from simple strategies to fundamental memory processes, differences that for these children are not found for visual perception.

Taking situation-specificity and domain-specificity together would suggest a more complex pattern of inter- and intra-individual differences in information processing. Such a complex pattern may be explained by the presence or absence of an explicit representation of context, thus explicit understanding of how each situation ties together a particular, but flexible set of different domains. A consequence of this interpretation would be that domains do not reflect specialized capacity spheres, but arise from the implicit elements of any mental representation. This view is espoused in the fourth cell of Figure 1. In this view the cultural frameworks of Benet-Martinez et al. (2006) thus might extend across domains only when an explicit recognition of any specific situation ties together its underlying domains. For example, a Japanese tea ceremony ties together domains of etiquette and physics for the social aspects of the ceremony and the preparation of tea. At the same time, the domains of Demetriou et al. (2005) might extend across many situations when actors have an explicit understanding of the similarities and differences of these situations, but do not have to generalize so broadly when this understanding is not explicit. For example, mathematical strategies learned in school might transfer to food preparation at home when

people recognize how exactly the preparation of food is both similar and different than classroom math. Herein also lies the practical implication of my dissertation. It seems as if education is too much focused on any domain in isolation. Children should be taught precisely how situations are similar and different and how domains may relate to each other in everyday life.

Cognitive transfer in everyday life is multifaceted. At the least, that is what research in my dissertation has shown. We follow Cole and Bruner (1971) by proposing that researchers need to invest their time by trying to determine how transfer may be improved. Transfer is strong in some situations, but absent in others (Barnett & Ceci, 2002; diSessa, 1993; Wagner, 2006). Exploring the precise nature of many situations will help to sort out the knowns and unknowns of transfer.

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Summary (in English)

The present thesis captures four studies that chart the connection between culture and cognitive development, starting quite distal by looking at country differences in Raven Matrices scores but growing gradually more proximal by zooming in on the processes and causes that produce or moderate cognitive transfer in childhood. Michael Cole aptly captured the distribution of cognition in time and how it relates to the individual child, in his book *Cultural Psychology: A Once and Future Discipline*. His model includes six time scales that frame children's experience: the history of the physical universe (geological time), the history of life on earth (phylogeny), the history of human beings on earth (cultural-historical time), the history of the individual's immediate context (ontogeny of the outside), the life of the individual himself (ontogeny), and the history of moment-to-moment lived experience (microgenesis). Through the parents or through schooling, the six transformations become materialized constraints on the child's experiences in the present. Parents' idealized recall of their past and idealized imagination of their child's future leads them to encourage and promote their child in particular ways and not others.

The four studies of this thesis address developmental transitions at the four lower times scales of this model of the distribution of cognition in time, ignoring the geological time and phylogeny. The first study addresses cultural-historical time in a meta-analysis of cultural and historical variation in Raven's Progressive Matrices. The Flynn effect is among the hypotheses considered. The second study addresses ontogeny of the outside in a cross-sectional comparison of schooling and everyday experiences and their separate contribution to cognitive development among Kharwar children in rural India. The third study is a longitudinal extension of the second study and addresses ontogeny of the child more directly than the second study, by looking at variations in impact of the different processes of cognitive development. The fourth and last study addresses microgenesis in a study of within-subject switches in the processing of two kinds of typicality, ideals and features, amongst Dutch monocultural and bicultural children. Each of the four study will

now be summarized separately.

The first chapter addresses variation in Raven's Progressive Matrices scores across time and place. Raven's Progressive Matrices are a series of multiple-choice items of abstract reasoning. Each item depicts an abstract pattern in a two by two or three by three matrix; all cells contain a figure except for the cell in the right lower corner. Participants are asked to identify the missing segment that would best complement the pattern constituted by the other cells among a set of alternatives that are positioned beneath the matrix. John C. Raven published the first version of the test in 1938; the three versions of the test (Advanced, Colored, and Standard Progressive Matrices) have since then been among the most widely-used intelligence tests. Its intuitively appealing question format and the use of figure stimuli have made the test attractive for cross-cultural comparisons. A meta-analysis of cross-cultural intelligence test scores found that the test takes a second place after the Wechsler Intelligence Scales for Children. This widespread usage makes the test an interesting instrument for a cross-cultural meta-analysis. Moreover, the period in which the Raven has been used in various countries is long enough for enabling a study of a temporal patterning of test scores.

Studies that report data on Raven's Progressive Matrices were located with help of library search engines and a request for data was sent to more than 200 authors. Data were analyzed of 798 samples coming from 45 countries ($N = 244,316$), which were published between 1944 and 2003. Country-level indicators of educational permeation (which involves a broad set of interrelated educational input and output factors that are strongly related to economic development), the samples' educational age, and publication year were all independently related to performance on Raven's matrices. Our data suggest that country differences in Raven performance reflect a Flynn effect that is present in high as well as low GNP countries. The tangible size of the Flynn effect is moderated by education-related sample and country characteristics and seems to be rather smaller in developed than in emerging countries.

The second chapter addresses an experiment of schooling and everyday cognitive development among Kharwar children in India. Schooling is a setting where teachers and pupils conspire to elevate pupils' extent of transfer. This conspiracy is motivated by the

perception that generalization offers an advantage in the processing of cognitive tasks that cannot be achieved with unique rules for each new task. Despite this perception, the processes that produce farther transfer in school are subject to discussion. On the one hand, there is the view that teachers labor to create new intellectual structures in children's repertoire. On the other hand, there is the view schooling broadens children's field of application of thinking, but that it does not really constitute new thought processes. A possible approach to unraveling individual differences in children's intellectual structure and transfer is the comparison of the effects of educational age and chronological age. Unfortunately, such a comparison appears difficult to implement in practice. Western-based studies may only employ highly correlated measures of chronological and educational age, which seriously limits their power to disentangle the products of these ages. Non-Western studies show another confounding, educational age tends to be related to socioeconomic status in these studies and thus create a sampling bias.

In order to avoid these confounds we took advantage of a particular setting among the Kharwar society in India, in which neither educational age and chronological age, nor schooling and status, are confounded, allowing a study design that avoids the usual limitations of studying the effects of schooling. The sample comprised 201 schooled and unschooled Kharwar children from six to nine years of age. The test battery contained measures of mathematics and memory with formal and local stimulus content, as well as tests of inductive reasoning, analogies, fluency, picture vocabulary, and numbers. Confirmatory factor analyses supported similar hierarchical factor structures, with general intelligence in the apex, for unschooled and schooled children. The per annum score increments of chronological age were about twice as large as those of educational age. These findings illustrate the role of everyday experiences in the development of cognitive functioning and that schooling broadens children's field of thinking.

The third chapter addresses a longitudinal study among Kharwar children in India of everyday and school-specificity of representational change. Children towards the end of middle childhood treat new information in ways that are quite a bit different from that of very young children. For very young children new information is associated with the categorization of behavior, human-made items, and living kinds, but for children towards

the end of middle childhood new information is associated with the transfer of properties and the consideration of similarity. A shift from categorization to transfer may be deduced from different lines of research, but so far evidence of this shift has been rather circumstantial. Previous research found that both everyday and school experiences contribute to children's cognitive development and that both kinds of age predict the achievement on cognitive exercises. To understand the nature of age-related changes in development, researchers in developmental psychology have begun to examine the implicit and explicit character of representation. Through dynamic self-organizing interaction between these two types of representation their developmental trajectories change shape. Development is triggered by new input, which can lead to changes in either children's implicit or explicit representation. This change in their representation has consequences for the way that future input could trigger development.

In order to find empirical support for this claim we examined the shift in cognitive development more directly by examining variation within children's modes of development across chronological age and educational age in India by means of a two-wave longitudinal design with a three-year interval. A longitudinal design in this particular setting allows us to take a closer look at intra-individual processes of change and to demonstrate how chronological age and educational age precisely relate to this shift. The sample comprised of 191 children aged between six and twelve years. Five measures of implicit and explicit representation were administered. Confirmatory analyses revealed two processes of development: One that reflects children's hierarchical construction of knowledge and another that reflects the actualization of knowledge across particulars. Analyses of the net development per year revealed a decrement of the effect of chronological age and an increase of the effect of educational age.

The fourth chapter addresses the natural variation of typicality in childhood by examining visual search of ideals and features in a multicultural context. The most representative member of a category is not always the exact same one. One book would be considered a better example of things that can be read than a drug prescription or a TV guide by most children and adults, but for most other categories the most typical example could be different for people of different ages, different cultural backgrounds, or even for

one person in different situations. The true nature of this variation has been examined extensively over the last decades, but studies often confound typicality and familiarity. Often, developmental studies and cross-cultural studies claim some strong form of specificity in preference for either features or ideals to define categories. Observing typicality and familiarity from a connectionist modeling perspective suggests that with each integration of new units into a representation, the average typicality of each unit declines. Thus with increasing familiarity of some concept the relevance of its features becomes smaller. Relevance seems to shift to the meaning that is shared by several units, the associations. In other words: with increasing familiarity, ideals become more typical.

In order to find empirical support for this claim we collected decision times of a total of 59 Turkish-Dutch and 58 Dutch primary school children (mean age is 11.09 years). The children completed a 96-item series of visual search tasks, in which they had to see whether a target that was presented to them first, was present in a subsequent set of distractors. Familiarity was manipulated by using both Turkish and Dutch items and typicality was manipulated by varying the difference between the targets and their own respective distractors. Main effects of familiarity and typicality were not significant, but their interaction was. Examination of the estimated marginal means revealed that low familiarity led to an advantage in the processing of features, whereas high familiarity to an advantage in the processing of ideals. Familiarity is necessary for typicality.

Taken together the four studies have critical implications for the conceptualization of culture and cognitive transfer in childhood. Differences are often taken as to reflect problems with the access or meaning of particular procedures, representations, and principles. Our findings question this approach to differences. Rather, differences are caused by the generation or prediction of new properties after the procedure, representation or principle has been correctly inferred from the premise. Schooling promotes the generation and prediction of properties in pupils and the promotion has much to do with enrichment of the pool properties children represent and have to draw from in making successful generalizations in their everyday life.

Summary (in Dutch)

Deze thesis bevat vier studies die de relatie tussen cultuur en cognitieve ontwikkeling in kaart brengt, vrij distaal beginnend door te kijken naar landsverschillen in scores op de Raven Matrices maar geleidelijk meer proximaal wordend door in te zoomen op de processen en oorzaken van de factoren die cognitieve ontwikkeling veroorzaken of sturen. Michael Cole ving de distributie van cognitie over tijd en hoe het verhoudt tot het kind goed in zijn boek *Cultural Psychology: A Once and Future Discipline*. Zijn model bevat zes schalen die de ervaringen van kinderen inkaderen: De geschiedenis van het fysieke universum (geologische tijd), de geschiedenis van leven op aarde (fylogenie), geschiedenis van de mens op aarde (cultuur-historische tijd), de geschiedenis van iemands directe omgeving (ontogenese van het uitwendige), het leven van het individu (ontogenese), en de geschiedenis van moment-tot-moment ervaring (microgenese). Door middel van de ouders of door middel van scholing, worden deze zes transformaties gematerialiseerde restricties op de ervaring van kinderen in het heden. Een geïdealiseerde herinnering van het verleden en een geïdealiseerde voorstelling van de toekomst van hun kind leidt ouders tot het aanmoedigen van hun kinderen op bepaalde manieren en niet andere.

De vier studies in deze thesis richt zich op de vier lagere schalen in dit model over de distributie van cognitie in tijd, dus geologische tijd en fylogenie buiten beschouwing latend. De eerste studie richt zich op de cultuur-historische tijd in een meta-analyse van culturele en historische variatie in Raven's Progressieve Matrices. Het Flynn-effect is een van hypothesen die aan bod komt. De tweede studie richt zich op de ontogenese van het uitwendige in een cross-sectionele vergelijking van scholing en alledaagse ervaringen en hun afzonderlijke bijdrages aan de cognitieve ontwikkeling van Kharwar kinderen in ruraal India. De derde studie is een longitudinale uitbreiding van de tweede studie en richt zich meer direct op de ontogenese van het kind dan de tweede studie, door te kijken naar de impact van verschillende ontwikkelingsprocessen. De vierde en laatste studie richt zich op microgenese in een studie van intra-individuele verschillen in de verwerking van twee

soorten kenmerkendheid, idealen en eigenaardigheden, bij Nederlandse biculturele en monoculturele kinderen. Elk van de vier studies zal nu beknopt worden besproken.

Het eerste hoofdstuk richt zich op variatie in Raven's Progressieve Matrices scores over tijd en plaats. Raven's Progressieve Matrices is een serie van meerkeuze items van abstract redeneren. Elk item verbeeldt een abstract patroon in een twee bij twee of drie bij drie matrix; elke cel bevat een figuur de cel in de rechter benedenhoek. Participanten wordt gevraagd om in een set van alternatieven die beneden de matrix is geplaatst het missende segment te identificeren dat het beste het patroon van de andere cellen complementeert. John C. Raven publiceerde de eerste versie van de test in 1938; sinds die tijd zijn de drie versies van de test (Geavanceerde, Standaard, en Gekleurde Progressieve Matrices) onder de meest gebruikte intelligentie testen. Het intuïtief aantrekkelijke vraag format en het gebruik van figuratieve stimuli hebben de test aantrekkelijk gemaakt voor crossculturele vergelijkingen. Een meta-analyse van crossculturele intelligentie test scores vond dat de test een tweede plaats in nam na de Wechsler Intelligentie Schalen voor Kinderen. Dit wijdverspreid gebruik maken de test een interessant instrument voor een crossculturele meta-analyse. Bovendien, de periode waarin de Raven is gebruikt in verschillende landen is lang genoeg om een studie van de temporele patronen in test scores mogelijk te maken.

Studies die data over de Raven's Progressieve Matrices rapporteren werden gelokaliseerd met hulp van bibliothecaire zoeksystemen en een verzoek voor data werd verzonden aan meer dan 200 auteurs. Data van 798 samples uit meer dan 45 landen ($N = 244316$), gepubliceerd tussen 1944 en 2003, werden geanalyseerd. Landsniveau variabelen van de doordrongenheid van onderwijs (waar het gaat om een brede set van geassocieerde onderwijs input en output factoren die sterk samenhangen met economische ontwikkeling), de hoeveelheid onderwijs voor iedere sample, en publicatie jaar waren alle onafhankelijk gerelateerd aan performance op Raven's matrices. De data suggereren dat landsverschillen in Raven performance een Flynn effect in zowel hoge als lage BNP landen reflecteert. De werkelijke grootte van het Flynn effect wordt gemodereerd door onderwijs gerelateerde sample en landskarakteristieken en lijkt kleiner in ontwikkelde landen dan in opkomende landen.

Het tweede hoofdstuk richt zich op een experiment van scholing en alledaagse

cognitieve ontwikkeling bij Kharwar kinderen in India. Scholing is een setting waarin leraren in leerlingen samenspannen om het vermogen tot transfer van de leerlingen te vergroten. Deze samenwerking wordt gemotiveerd door de observatie dat generalisatie een voordeel in het verwerken van cognitieve taken biedt die niet kan worden bereikt door het leren van unieke regels voor elke nieuwe taak. Ondanks deze observatie zijn de processen die verre transfer mogelijk maken onderwerp van discussie. Aan de ene kant is er de visie dat leraren hun best doen om nieuwe intellectuele structuren in het repertoire van kinderen aan te brengen. Aan de andere kant is er de visie dat scholing het toepassingsgebied van het denken van kinderen verbreedt, maar dat dit niet bestaat uit nieuwe denkprocessen. Een manier om individuele verschillen in intellectuele structuur en transfer uit elkaar te trekken is een vergelijking van de effecten van het aantal jaren scholing en chronologische leeftijd. Jammer genoeg is een dergelijke vergelijking moeilijk te realiseren. Westerse studies kunnen hoge correlatie tussen aantal jaren scholing en leeftijd niet vermijden, wat het vermogen om de twee uit elkaar te trekken aanzienlijk beperkt. Niet-westerse studies vertonen een andere verwarring: aantal jaren scholing is in deze studies geneigd om samen te hangen met sociaaleconomische status en dus tot de creatie van sample bias.

Om deze verwarring te vermijden hebben we gebruik gemaakt van een bijzondere setting in de Kharwar gemeenschap in India, waar zowel aantal jaren scholing en leeftijd als aantal jaren scholing en sociaaleconomische status niet met elkaar samenhangen, en dus een studie design mogelijk maakt die de gebruikelijke beperkingen van de studies van de effecten van scholing vermijdt. De sample bestaat uit 201 geschoolde en ongeschoolde Kharwar kinderen in de leeftijd van zes tot negen jaar. De test batterij bestaat uit wiskunde en geheugen met zowel formele als alledaagse stimulus inhoud en testen van inductief redeneren, analogieën, ideebeheersing, vocabulaire, en getallen. Confirmatorische factoranalyse onderbouwd gelijke hiërarchische factor structuren, met algemene intelligentie in de top, voor zowel geschoolde en ongeschoolde kinderen. De score toename per jaar was tweemaal was ongeveer twee maal zo groot voor leeftijd als voor scholing. De bevindingen illustreren de rol van alledaagse ervaringen in de ontwikkeling van cognitief functioneren en dat scholing de toepassing van denken verbreedt.

Het derde hoofdstuk richt zich op een longitudinale studie van alledaagse en school

specificiteit van de verandering in representatie bij Kharwar kinderen in India. Kinderen aan het eind van de middenkindertijd bejegenen nieuwe informatie op manieren die vrij anders zijn dan de manieren waarop jonge kinderen dat doen. Voor heel jonge kinderen is nieuwe informatie geassocieerd met de categorisatie van gedrag, door mensen gemaakte artefacten, en levende dingen, terwijl voor kinderen aan het eind van de middenkindertijd is nieuwe informatie geassocieerd met de transfer van eigenschappen en het in aanmerking nemen van overeenkomst. Een verschuiving van categorisatie naar transfer mag worden herleid uit verschillende lijnen van onderzoek, maar tot dusver is het bewijs voor deze verschuiving omstandig. Eerder onderzoek liet zien dat zowel alledaagse als schoolse ervaringen bijdragen aan de cognitieve ontwikkeling van kinderen en dat beide ervaringen het succes op cognitieve oefeningen voorspellen. Om de werkelijk achtergrond van de leeftijdsgerelateerde veranderingen te begrijpen zijn ontwikkelingspsychologen begonnen met het onderzoeken van de impliciete en expliciete eigenschappen van representatie. Door middel van dynamische zelfregulerende interactie tussen de twee types van ervaring wordt de hun richting gevormd. Ontwikkeling start met nieuwe input, wat vervolgens kan leiden tot verandering in oftewel de impliciete oftewel de expliciete representatie van kinderen. Deze verandering in representatie heeft een verandering in manier waarop toekomstige input wordt bejegend tot gevolg.

Om empirische steun voor deze bewering te vinden, hebben wij de verschuiving in cognitieve ontwikkeling meer direct bestudeerd door te kijken naar variatie in de vorm van ontwikkeling over leeftijd en aantal jaren scholing in India met hulp van een longitudinaal onderzoek met twee metingen over een interval van drie jaar. Een longitudinaal design staat in deze setting een nauwkeurigere blik op intra-individuele processen van verandering toe en stelt ons in staat om de precieze relatie van leeftijd en scholing met de verschuiving aan te tonen. De sample bestaat uit 191 kinderen in een leeftijd van zes tot twaalf jaar. Vijf maten voor impliciete en expliciete representatie werden afgenomen. Confirmatorische factor-analyse onthulde twee processen van ontwikkeling: Een die de hiërarchische constructie van kennis omvat en een andere die de actualisatie van kennis over details bevat. Analyse van de netto ontwikkeling per jaar laat een afname in de ontwikkeling over leeftijd zien en een toename in de ontwikkeling over jaren scholing.

Het vierde hoofdstuk richt zich op natuurlijk variatie in kenmerkendheid tijdens de kindertijd door visueel zoeken van idealen en eigenaardigheden te onderzoeken in een multiculturele context. Het meest representatieve lid van een categorie is niet altijd precies dezelfde. Een boek is een beter voorbeeld voor iets wat je kunt lezen dan een televisiegids of een doktersrecept voor de meeste kinderen en volwassenen, maar voor veel categorieën zal het meest kenmerkende voorbeeld anders zijn voor mensen van verschillende leeftijden, met verschillende culturele achtergronden, of zelfs voor dezelfde persoon in verschillende situaties. De ware natuur van deze variatie is extensief bestudeerd in de laatste decennia, maar studies verwarren vaak kenmerkendheid en bekendheid. Vaak claimen crossculturele en ontwikkelingspsychologische studies een sterke vorm van specificiteit in preferentie voor enerzijds opvallende eigenaardigheden of anderzijds idealen om categorieën mee te definiëren. Observatie van kenmerkendheid en bekendheid vanuit een netwerk benadering suggereert dat met elke integratie van een nieuwe eenheden in de representatie, de gemiddelde kenmerkendheid van de elke eenheid daalt. Dus met toenemende bekendheid met een zeker concept neemt de relevantie van losse kenmerken af. Relevantie verschuift naar de betekenis die wordt gedeeld door meerdere eenheden, de associaties. Met andere woorden: Met toenemende bekendheid worden idealen meer kenmerkend.

Om empirische steun voor deze bewering te vinden, hebben we reactietijd van in totaal 59 Turks-Nederlandse kinderen en 58 Nederlandse kinderen (met een gemiddelde leeftijd van 11.09 jaar) verzameld. De kinderen voltooiden een 96-item serie van visuele zoektaken, voor welke ze moesten zien of een afbeelding die eerst was gepresenteerd zich bevond tussen een daarop volgende set van afleidende afbeeldingen. Bekendheid werd gemanipuleerd door zowel Turkse als Nederlandse te gebruiken, terwijl kenmerkendheid werd gemanipuleerd door de verschillen tussen de target afbeeldingen en de desbetreffende afleidende afbeeldingen te variëren. Hoofdeffecten van bekendheid en kenmerkendheid waren niet significant, maar hun interactie wel. Analyse van de geschatte gemiddelden onthulde dat lage bekendheid tot een voordeel in het verwerken van eigenaardigheden leidde, terwijl hoge bekendheid leidde tot een voordeel in het verwerken van idealen. Bekendheid is noodzakelijk voor kenmerkendheid.

Gezamenlijk hebben deze vier studies kritische implicaties voor de conceptualisatie

van cultuur en cognitieve transfer in de kindertijd. Verschillen worden vaak geaccepteerd als gevolg van problemen met de toegankelijkheid of betekenis van specifieke procedures, representaties, of principes. Onze bevindingen trekken deze benadering in twijfel. Eerder lijken verschillen voort te komen uit het vrijmaken of voorspellen van nieuwe opvallende eigenaardigheden nadat de procedures, representaties, of principes al zijn geïnterfereerd van de premisse. Scholing bevordert het vrijmaken of voorspellen van nieuwe opvallende eigenaardigheden in leerlingen en deze bevordering heeft veel te doen met de verrijking van de pool van eigenaardigheden die kinderen representeren en waarop ze moeten terug vallen bij het maken van succesvolle generalisaties in het dagelijkse leven.